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SURVEY REPORT

ROANOKE RIVER WATERSHED

VIRGINIA · NORTH CAROLINA

program for runoff and waterflow retardation-and soil erosion prevention

U. S. DEPARTMENT OF AGRICULTURE

~~SEPTEMBER 1950~~
JULY 1951

17315

UNITED STATES DEPARTMENT OF AGRICULTURE

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ROANOKE RIVER WATERSHED

VIRGINIA AND NORTH CAROLINA

Program for Runoff and Waterflow Retardation and
Soil Erosion Prevention

Pursuant to the Act approved June 22, 1936 (49 Stat. 1570),
as amended and supplemented

July 1951

1795

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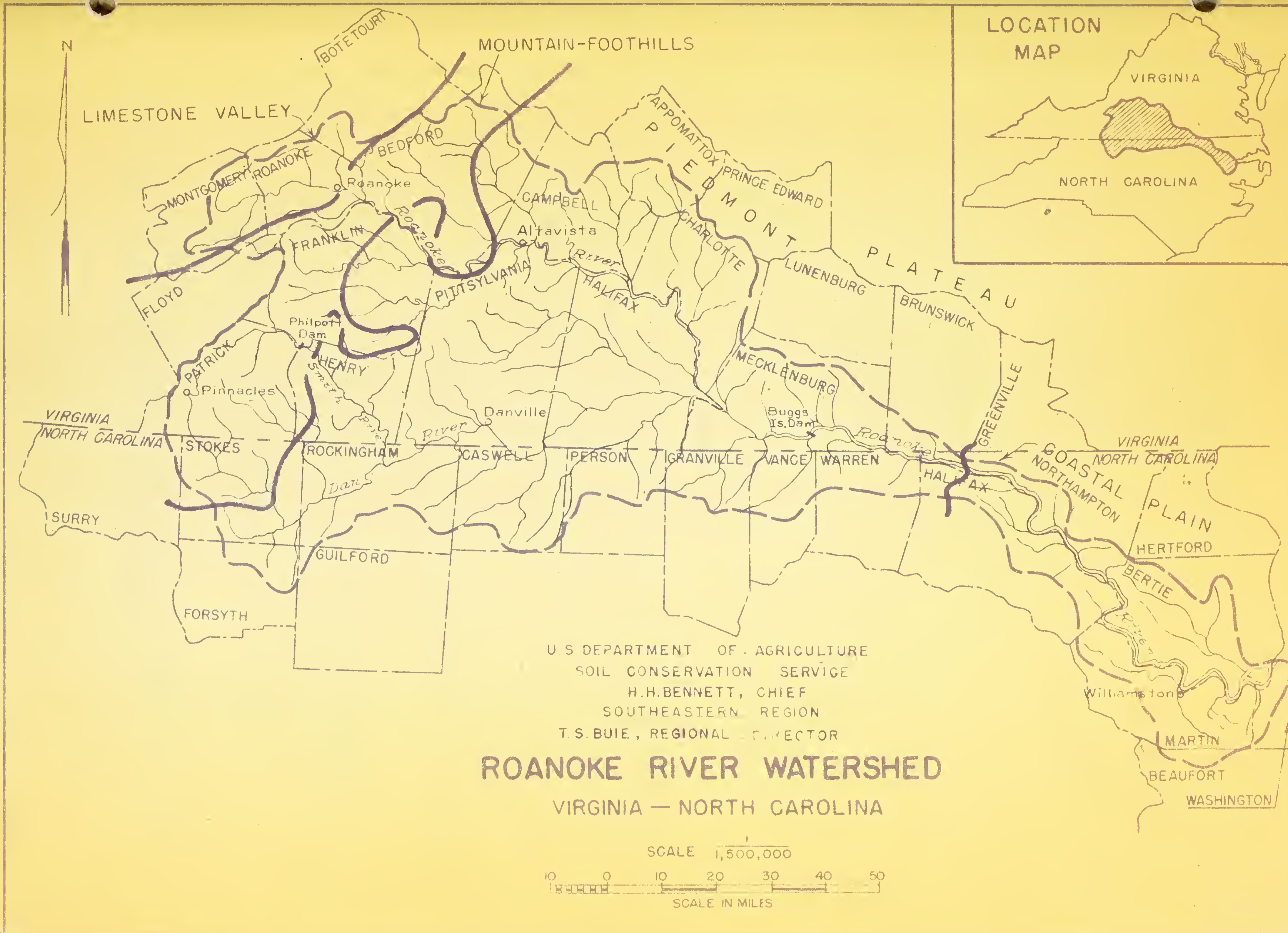
LOCATION MAP
VIRGINIA
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N
LIMESTONE VALLEY
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BOTETOURT
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H.H. BENNETT, CHIEF
SOUTHEASTERN REGION
T.S. BUIE, REGIONAL DIRECTOR
ROANOKE RIVER WATERSHED
VIRGINIA — NORTH CAROLINA
SCALE 1/1,500,000
10 0 10 20 30 40 50
SCALE IN MILES

2-L-5509

INTRODUCTION

Authority

This report is submitted under the provisions of the Act approved June 22, 1936 (49 Stat. 1570), as amended and supplemented.

Purpose and Scope of Report

The purpose of this survey report is to outline a program of runoff and waterflow retardation and soil erosion prevention for the Roanoke River Watershed in Virginia and North Carolina and to present recommendations for the installation and maintenance of the program, together with an analysis of the cost and benefit.

RECOMMENDATIONS

It is recommended that a program of runoff and waterflow retardation and soil erosion prevention be installed during a 20-year period in the Roanoke River Watershed at an estimated cost of $11,645,600 to the Federal Government, and at an estimated cost of $6,911,900 or its equivalent[1/] to local interests, making an estimated total cost of $18,557,500 for the installation of the complete program.

The program will be operated and maintained at an estimated annual cost of $112,600 to the Federal Government, and $5,403,500 or its equivalent to local interests, making an estimated total annual cost of $5,516,100.

1/ Labor, materials, equipment, land, easements, rights-of-way and other contributions in lieu of cash payments.

The recommended program has as its objectives the reduction of floodwater and sediment damage, and the conservation of soil and water resources. The interdependent measures that will accomplish these objectives are as follows: Subwatershed waterways, gully stabilization and sediment control, erosion control along roads and railroads, diversion channels, terraces, field borders, farm waterways, mountain watercourse control, adequate fire control, woodland management, tree planting, land acquisition, tributary channel improvement and streambank stabilization, and other soil and water conservation practices and measures.

Educational assistance and technical services will be provided and will be synchronized and adapted toward the specific objectives of floodwater and sediment damage reductions.

The Secretary of Agriculture may make such modifications or substitutions of the measures described in this report as may be deemed advisable due to changed physical or economic conditions or improved techniques, whenever he determines that such action will be in furtherance of the objective of the recommended program.

It is estimated that the recommended program will yield an average annual flood-control benefit of $474,000. In addition to this flood-control benefit, an estimated average annual benefit of $15,153,700 from erosion control, conservation farming and woodland management will accrue to the owners and operators of farm land, timber land, railroads, highways, and lands to be acquired for watershed protection.

The ratio of the estimated average annual value of the total benefit to the average annual value of the total cost of the recommended program is 2.11 to 1.[1/]

The recommended measures will be installed on non-Federal land under cooperative arrangements with State and local governments, soil conservation districts, or other agencies acceptable to the Secretary of Agriculture.

The program herein recommended includes the intensification, acceleration, and adaptation of certain activities under current programs of the Department of Agriculture, and additional measures not now regularly carried out in such programs, all of which are necessary to complete a balanced runoff and waterflow retardation and erosion control program for the watershed. It is recommended that the Secretary of Agriculture be authorized to carry out this program. The extent to which the work recommended in this program is to be carried out under authority of the Flood Control Act as requested herein or under other authorities will be considered by the Secretary in requesting appropriations for the conduct of the recommended program. Although the current activities of the Department primarily related to the Flood Control Act are not included in the program herein specifically recommended, this program is based on the continuation of such current activities at least at their present level. The extent to which the measures in the recommended program may be carried

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1/ Comparison of benefits and costs based on future price and cost levels assumed to prevail under a high level of employment, with delayed costs and benefits discounted.

out by an increase in the current programs of the Department will be taken into account in requests for the appropriation of funds to carry out the recommended program.

The authority of the Secretary of Agriculture to prosecute the recommended program shall be supplemental to all other authority vested in him, and nothing in this report shall be construed to limit the exercise of powers heretofore or hereafter conferred on him by law to carry out any of the measures described herein or any other measures that are similar or related to the measures described herein.

The Secretary of Agriculture may construct such buildings and other improvements as are needed to carry out the measures included in the recommended program.

DESCRIPTION OF THE WATERSHED

6,131,200

The Roanoke River Watershed comprises an area of 9,580 square miles, of which 6,160 (3,942,400) square miles are in Virginia and 3,420 (2,188,800) square miles in North Carolina (figure 1).

The Roanoke River rises in the Limestone Valley area west of Roanoke, Virginia, and discharges into the Atlantic Ocean at Batchelor Bay at the western end of Albemarle Sound. The principal tributary is the Dan River which has a watershed of 3,855 square miles.

The watershed area contains four natural subdivisions (figure 1).

1. The Limestone Valley area comprises about 5 percent of the watershed. The topography ranges from level and undulating to mountainous. Stream channels are well defined with adequate capacities and their gradients are generally high. Flood plains are comparatively narrow and flood damages small.

2. The Mountain-Foothills area comprises about 18 percent of the watershed. It is a steep and rugged section, predominantly wooded, with narrow valleys and high stream gradients.

3. The Piedmont Plateau area comprises about 64 percent of the watershed. It is the most highly developed agricultural section of the watershed and contains large urban and industrial centers. Sheet and gully erosion are severe and runoff is relatively rapid.

4. The Coastal Plain area comprises about 13 percent of the watershed. It is flat to gently rolling in topography except along the Fall Zone which is steeply rolling. Flood plains are wide and well developed and stream gradients are low.

Approximately 57 percent of the watershed is in woodland, 19 percent in cultivation, 7 percent in pasture, 6 percent idle land, and 11 percent in miscellaneous uses. Most of the woodland is in poor to mediocre condition in terms of runoff and soil stability because of fire, grazing, overcutting, improperly maintained roadways, and destructive logging. Much of the open land is seriously eroded because of poor management practices, and pastures

are commonly unimproved, trampled, and overgrazed. A considerable acreage of the bottom land subject to flood overflow is used for agricultural purposes, and a much larger area has been so used at various times in the past, but is not cultivated now because of overwash of infertile sediment, scour damage and the increased flood hazard.

The average annual precipitation ranges from 41 inches in the Limestone Valley to 58 inches at Pinnacles, Virginia, in the mountains. An average of 49 inches occurs at Williamston, North Carolina, in the Coastal Plain.

The population of the watershed in 1940 was approximately 663,000, of which about 74 percent lived in rural areas. In 1945, farm tenancy ranged from about 4 percent in Montgomery County, Virginia, in the Limestone Valley area to about 71 percent in Northampton County, North Carolina, in the Coastal Plain area.

Agriculture is the principal enterprise in the watershed. Tobacco, peanuts, and cotton are the main cash crops. Timber products are manufactured in considerable quantity. The principal industries are tobacco processing, textiles, lumber, pulp and furniture manufacturing.

The watershed is served by excellent transportation systems of airlines, highways, and railroads. Many of the roads are located in the valleys adjacent to the streams and are subject to the damaging effects of floods.

FLOOD PROBLEMS

The size of the area, physiographic variations, and storm characteristics are such that no recorded storms have produced floods simultaneously in all parts of the Roanoke River Watershed.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Major floods in the Roanoke River basin are most common during the late summer, fall, and winter months. The summer floods are usually due to storms of the tropical hurricane type, with intense rainfall. The winter and late fall floods are normally due to storms with sustained rainfall of less intensity. Occasionally winter storms with intense rainfall occur and produce great floods, such as that of March 1912.

The August 1940 flood was the greatest of record on the Roanoke River below Roanoke, Virginia, and above Roanoke was exceeded only by floods before 1900, such as the November 1877 flood. The August 1940 storm caused one of the greatest floods of record on the lower Dan River, being exceeded only by the 1877 flood, although nearly equaled by the 1912 flood.

Violent local storms in the mountain areas create flash floods, the force of which is dissipated before the flood flows progress very far downstream. However, those floods cause local damages to stream banks and channels and to the adjoining bottom lands. Also, prolonged rains in the Piedmont Plateau area cause overflows of longer duration on tributary streams, but these flows are often absorbed by the main stream without any appreciable rise in stage.

Destruction of growing crops is the largest item of flood damage in the watershed. Of all crop damages, approximately 94 percent occurs on the bottom lands of tributary streams and only 6 percent occurs on the flood plain of the main stem.

Roanoke and Danville, Virginia, are the largest towns that suffer significant urban and industrial damages. Serious damage to highways and railroads occurs mainly during major floods.

Other damages which were considered but not evaluated in monetary terms in this report include loss of life, illness caused by floods, personal injuries, insecurity of property and income, disruption of public services and education, and costs of relief and emergency sanitation. The prevalence of these hazards, however, furnishes additional incentive for the program recommended in this report.

The highest rates of runoff occur on the unimproved, trampled, overgrazed pastures, idle lands, and other steep uplands including woodlands which are grazed, heavily overcut and repeatedly burned. Approximately 71 percent of the woodland area is classed as poor from the standpoint of runoff retardation.

The most critical runoff and sediment source areas are the more seriously eroded portions of the Piedmont Plateau and Mountain-Foothills area. Gullies are the most serious source of the coarser grained sediments. It is estimated that in the entire watershed there are 289,000 acres of land with occasional gullies (3 or less per acre), 49,500 acres of land with frequent gullies (3 or more per acre), and about 4,800 acres of land more than 75 percent gullied.

is this an understatement
description accurate? How long, how wide, how deep

Unprotected drainageways and cut and fill slopes are another important source of runoff and sediment. Much of the material which is eroded from unprotected cut and fill slopes along highways and railroads is transported to the stream channels or is deposited on productive agricultural land.

In the Piedmont Plateau deposition of infertile materials, largely sand, has damaged 17.2 percent of the flood plain. Scouring of topsoil and channel cutting by floodwaters have affected

3.8 percent of the bottom lands. Swamping occurs only in isolated local areas.

In the Mountain-Foothills area 5.5 percent of the bottom lands have been damaged by deposition and 2.9 percent by scour.

Scour affects 6.1 percent of the flood plain in the Limestone Valley area. Deposition is of very limited occurrence.

Sediment and related damages are of minor importance in the Coastal Plain area.

Stream bank erosion is of general occurrence although extensive damage takes place only during major floods. Most stream banks are heavily vegetated. Newly constructed channels, however, should be protected from bank erosion by vegetative plantings.

Sedimentation is damaging the retention type reservoirs many of which are already filled or are rapidly filling with sediment.

The cost of treating public and industrial water supply depends to a considerable extent on the amount of suspended material carried by the water to be treated. Turbidities are greatly increased during flood periods, adding to the cost of water treatment.

Sediment damages to navigation and drainage channels, public health, crops, and property, have been recognized, but were not evaluated in monetary terms in this report. The effect of reduced turbidities on fish values was considered, but the benefits were not used as a part of the monetary justifications for the program.

The estimated average annual monetary damages in the Roanoke River Watershed are distributed as follows: Floodwater damage to crops and pasture, 67 percent; reservoir sedimentation damage,

4 percent; costs of water treatment, 16 percent; land damage including sanding, swamping, and scour, 3 percent; and damage to roads and railroads, 10 percent.

Table 1 lists the estimated average annual monetary damages in the Roanoke River Watershed.

Table 1.--Estimated average annual monetary damages in the Roanoke River Watershed

Type of damage	Average annual damage (1946 prices)	
	dollars	
Floodwater damages		
Agricultural - crop and pasture	1,439,500	
Non-agricultural - roads and railroads	211,800	
Sub-total		1,651,300
Sediment and land damages		
Reservoir sedimentation	86,600	
Water treatment costs	339,100	
Land damage (sanding, swamping and scour)	69,500	
Sub-total		495,200
Total average annual damage		2,146,500

ACTIVITIES RELATED TO FLOOD CONTROL

The Department of the Army, Corps of Engineers, has developed a comprehensive plan of improvement for the Roanoke River basin, consisting of 11 developments for hydroelectric power, flood control, navigation, and other uses. This plan is described in House Document 650, 78th Congress, which is a review of the original report on the Roanoke River basin, House Document No. 65, 74th Congress.

Two developments, the Buggs Island project on the Roanoke River and the Philpott project on the Smith River, are now under construction. There are approximately 70,300 acres of Federal lands adjacent to the Buggs Island and Philpott reservoir areas, which are now being administered by the Department of the Army, Corps of Engineers.

The Department of the Interior administers 3,444 acres of National Park Land on which various conservation practices are being applied.

The Department of Agriculture, through its various agencies, is actively cooperating with State and local agencies in carrying out programs for the conservation of soil, water, and timber resources. State forestry agencies, in cooperation with the Forest Service, protect private woodlands against fire, provide technical assistance to owners in the proper management of their woodlands, and make trees available for reforesting open and poorly stocked forest land. The Production and Marketing Administration offers financial assistance to farmers for carrying out soil and water conservation practices. The Department also cooperates with State Extension Services and Experiment Stations in educational and research work in the conservation of soil and water resources. The Soil Conservation Service is currently assisting soil conservation districts in the application of soil and water conservation measures on farm lands. The present annual Federal cost of those portions of the Department's "going" programs which produce flood control and associated benefits is approximately $934,300.

The Soil Conservation Service, under the Bankhead-Jones Farm Tenant Act, administers a Land Use project of 14,061 acres in Caswell County, North Carolina.

The Forest Service administers and protects approximately 12,448 acres of national forest land which was acquired for watershed protection and for timber production.

Soil conservation districts, organized under State laws, cover the entire watershed area, and are actively engaged in a program of soil and water conservation and land management on farm lands, with technical assistance from the Soil Conservation Service, and with the cooperation of other Federal, State and local agencies.

Although the primary purpose of the conservation programs in the area has been the maintenance of soil resources and improvement of crop and timber yields, they have produced some flood control benefits.

The states of Virginia and North Carolina have done a limited amount of erosion control work along the principal highways.

RECOMMENDED PROGRAM

The program of runoff and waterflow retardation and soil erosion prevention recommended in this report was developed from a study of representative sample areas. The present condition of sample areas and minor watercourses was considered in detail to determine the types and quantities of practices and measures that would be most effective in reducing floodwater and sediment damages. The data derived by the sampling procedure were applied to relatively similar areas to estimate total requirements of the most beneficial and practical works of improvement for runoff and

waterflow retardation and soil erosion prevention.

The recommended program will accomplish a substantial decrease in floodwater and sediment damage and an increase in the productivity of watershed lands. Practices and measures will be installed primarily for retarding or controlling water from the time it reaches the land until the excess flows are discharged into the major streams. Some measures will be installed to increase the absorptive capacities of the soils, while others will be installed to conduct runoff that cannot be absorbed by the soils along the least damaging route to the major streams. Additional measures will be used to trap or screen out sediment that is not otherwise controlled. All of these measures installed in the proper combination and sequence will be necessary to provide for the most practical and effective utilization of rainfall and orderly management of runoff. Since the program of recommended measures was developed to function as a whole, each integral measure will be designed to function most effectively in combination with the others. The income of farm and woodland owners and operators is expected to increase materially as the recommended program becomes progressively effective. No major changes in the acreages of cash crops are involved, and it is anticipated that the principal cash crops will continue to be cotton and tobacco with some fruits and vegetables in localized areas. The greatest increases in acreage will be in pasture, perennial hay crops, and woodland.

The program will be carried out during a period of 20 years. Works of improvement will be installed, operated, and maintained largely by the landowners, operators, and other local interests. The scheduling of Federal participation will be dependent upon the rate with which local cooperation develops. The quantities of measures shown in table 2 are based on total watershed needs less the estimated accomplishments under "going" programs of the Department over a 20-year period.

The recommended program consists of the following interrelated and interdependent measures:

<u>Subwatershed Waterways</u>.--Reshaping of waterways to obtain broad watercourses of adequate capacity with low velocities of flow, as well as the application or installation of protective vegetation and structural controls for stabilization, will be provided to reduce flood and sediment damage. Where necessary, waterways will be extended across flood plains to dispose of surplus water.

A small amount of floodwater storage will be provided for in some of the structures used in the water disposal systems for subwatersheds in order to reduce the installation cost of other measures in the systems

and to provide protection to flood plain lands and improvements. These small detention type floodwater storage structures will be used to stabilize water disposal systems in headwater areas. They will consist of small earth-fill dams with an outlet to release water at a fixed and safe rate and with auxiliary spillways adapted to site conditions.

Gully Stabilization and Sediment Control.--Gullies are one of the principal sources of sediment. They extend up the slopes and expand into a gully system which progressively increases in depth, size, and area of destructiveness. Concentration of run-off in the gully channels creates sluiceways for the transport of erosional debris to lower streams and valley lands. Active gullies are contributing largely to the deposition damage problems. Gully treatment emphasizing vegetative stabilization with perennials such as kudzu, Lespedeza sericea, and local shrubs will be provided. Other types of controls including gully control dams and other structural means will be utilized. Drainage from overlying areas will be diverted from the gullies into stabilized waterways.

The gully stabilization work will be designed to decrease the volume of sediment originating in active gullies, reduce the rate at which land is being destroyed by gullies, and retard the present rapid concentration of runoff. At the mouth of some of these large gullies, or at a point of concentration of a sediment producing area, temporary earth dams for sediment control will be constructed. These structures will be supplemented with plantings of deep rooted shrubby perennials or trees which will provide effective protection throughout the year over a long period of time. Temporary dikes and diversion ditches will be used to afford protection until the vegetative plantings are established.

<u>Erosion Control Along Roads and Railroads</u>.-- Unprotected slopes of earth excavation and embankments for roads and railroads and along outfall ditches are major silt producing sources. In many cases, adequate water disposal measures have not been adopted and installed, and terraces often discharge directly down steep slopes of road cuts and into road ditches. These conditions are conducive to extensive erosion, and large volumes of sand and silt are washed downstream to fill stream channels and to spread over fertile bottom lands.

Reshaping of back slopes on both cut and fill sections and roadside ditches, vegetative plantings, and mechanical measures will be provided for more orderly control and disposal of storm runoff and reduction of the volume of sediment originating along road and railroad rights-of-way.

Diversion Channels.--Diversion channels will be installed on slopes too steep for terraces and where orderly discharge of surface runoff is necessary for the protection of lands lying immediately below them.

Terraces.--Terraces will be installed to manage the runoff from sloping lands, principally those in cultivation, and to reduce soil erosion and sediment production. They will direct the surface runoff not otherwise disposed of into water-disposal systems.

Field Border Plantings.--The narrow strip of land along field borders often left idle is a source of serious erosion and presents annoying runoff problems. Field borders will be established to furnish protection against these problems and will be improved for useful production. Vegetation of field borders will prevent woods from encroaching on the fields, provide vegetated drains where needed to carry off excess water from the ends of furrows, control erosion, and produce food, cover, protection, and other wildlife benefits.

Farm Waterways.--Natural and artificial farm waterways have been severely damaged by gullying and in many cases where protective measures have been applied they have not been properly installed and maintained. The improvement of existing drainageways and the installation of new waterways will be provided to permit the safe disposal of excess water from farms. Farm waterway improvements will consist of vegetated drainageways such as broad type meadow strips, V-shaped vegetated channels, and grassed or sodded terrace outlets. Supporting structures will be installed to implement vegetative control. Waterways on individual farms will be planned and installed in accordance with natural drainage of adjacent farms so that the waterways will function as a unit. The stabilized farm waterways and outlets will reduce sediment yields and land destruction resulting from uncontrolled runoff.

Mountain Watercourse Control.--Small headwater rock or brush dams, lead-off or diversion ditches, and similar devices will be installed, and deep-rooted species planted in and along the channels and gullied tributaries of the Mountain-Foothills area to help reduce sediment movement, channel scour and bank cutting, and to retard flood flows. This phase of mountain forest land improvement will be tied in with the protection and development of good forest and other permanent cover so as to achieve maximum benefits.

Adequate Fire Control.--Approximately 85 percent of the watershed is now under organized forest fire control. Fire protection currently afforded the area in Virginia has reduced the average annual burn to less than the 1/10 of one percent believed to be adequate for watershed protection. However, increased fire protection will be required in order to meet this objective within the watershed area in North Carolina where about 300,000 acres are not now receiving organized fire protection. An adequate fire protection system for areas in need of strengthened effort will be established and maintained, including necessary buildings. Reducing the forest area burned will increase the area of forest soils with optimum infiltration and water holding capacity.

Woodland Management.--The objective of woodland management will be to build up and maintain a forest cover which will in turn build up and maintain a good forest floor. Improvement of the forest floor will increase infiltration and soil moisture storage capacities. Under such conditions surface runoff and erosion will be reduced. Management measures applied to improve woodland hydrologic condition will develop thrifty, reasonably well stocked timber stands which will gradually provide higher and more sustained income from forest products. This increase in forest productivity will act as further incentive for woodland owners to participate in the program.

Technical services and advice on timber-sale marking and cultural operations will be aimed at building up and maintaining an adequate forest cover to protect and safeguard soil-water relationships.

Closely related attention will be given to logging methods, including location and condition of logging roads and skid trails. Many logged-over areas in the watershed are interlaced with old logging roads and skid trails that are serving as active drainageways for concentrated runoff and erosion. The program contemplates remedial measures, such as water-spreading devices, on deteriorated roads and skid trails. In addition, technical advice and assistance will be given the landowner on proper location of needed new logging roads and trails, as well as proper maintenance and care of the logging road and trail system to prevent water loss and damage.

Grazing by livestock, mainly as a result of trampling, is injurious to the good hydrologic condition typical of forest soils under good forest cover. In order that the forest soils may be fully effective in their function of storing water and reducing surface runoff, livestock will be excluded from some 150,000 acres of forest land which is now being overgrazed.

Tree Planting.--A forest cover will be established by planting trees on approximately 147,200 acres scheduled for conversion to forest land. Trees will also be

planted when needed on poorly stocked forest areas to improve the cover. Establishment of a forest cover on these open and partially denuded areas will reduce erosion and improve infiltration rates and detention storage capacity of the soils, thereby reducing runoff.

Land Acquisition.--Approximately 70,000 acres of land, critical flood water and sediment source areas, will be acquired by public agencies for watershed protection. Such land is generally rough, steep, stony land located on upper slopes and ridge tops. Because of the poor quality of this land and the low returns derived, it is not being adequately managed for either watershed protection or timber production. Public management of such land will assure the installation and maintenance of the recommended measures and practices. Approximately 10,000 acres of the area is located within the Jefferson National Forest and will be acquired by Federal purchase. The remaining 60,000 acres will be purchased by state and other public agencies.

Tributary Channel Improvement and Streambank Stabilization.--This measure, consisting of clearing and removing debris, enlarging and straightening channels, and establishing suppressive and protective vegetation on the banks of streams, will be installed to regulate the movement of floodwater, provide an immediate reduction in flood stages along tributary channels, and permit a more productive use of fertile flood plain land.

Other supporting farm and forest conservation practices and measures will be applied to facilitate the installation of and make the preceding measures more effective. The resulting combination will produce a practical and workable program that will be efficient in providing runoff and waterflow retardation and soil erosion prevention.

Landowners and operators and others in the watershed will be furnished educational assistance relative to the need for the recommended program and its purposes and objectives. Information will be supplied as to the manner in which landowners and operators now obtain services and assistance that are available through the various governmental agencies and how they can and should by their own efforts contribute successfully and most economically to the accomplishment of the overall objectives. Intensified educational efforts will be directed toward familiarizing farmers with the specific practices essential to waterflow retardation and soil erosion prevention; and how to install and apply those measures not requiring the detailed assistance of a specialized technician, how to maintain such installation and measures, and how to integrate all into the soundest farming system to produce the greatest benefit over a long period of time.

The Department of Agriculture is committed to a watershed and subwatershed approach in carrying out its responsibilities under the Flood Control Acts. It is essential that educational assistance provided under the recommended program be directed toward furthering the specific objectives of floodwater and sediment damage reduction and that it be fitted as to method and synchronization

into subwatershed operations activities.

Technical services will be provided for (1) planning and applying woodland improvement measures and management practices for watershed protection, (2) growing and harvesting timber crops, (3) planning and applying land use adjustments, (4) planning and applying conservation measures on the farm, and (5) integrating the installation of individual measures for both the "going" and recommended programs into a proper combination to achieve the most effective program of runoff and waterflow retardation and soil erosion prevention. These services will be supplied to assist the people in the watershed in installing the recommended measures on their land and in adopting the recommended practices for their farm and woodland operations.

COST OF THE RECOMMENDED PROGRAM

The estimated cost of installing the recommended program in the Roanoke River Watershed is approximately $18,557,500. Of this amount, it is estimated that the Federal Government will expend $11,645,600; non-Federal public agencies, $2,393,000; and private interests, $4,518,900. The estimate of total costs and the apportionment of costs to the Federal Government, non-Federal public agencies, and private landowners and operators are based on experience in the application of practices and measures similar to those recommended in this report.

Federal participation will include educational assistance, technical services, materials, planting stock, special equipment, and other direct aids where appropriate and needed to assist in the installation and maintenance of the recommended practices and measures.

The cost and the responsibility for the installation of any phase of the recommended program that is assigned in this report to the Federal Government may be assumed by state or local governments or responsible local agencies. It is anticipated that the estimated Federal cost can be reduced as a result of a greater realization upon the part of the landowners of the advantages of installing the recommended practices and measures. State and local agencies will be urged to participate in the program to the fullest extent possible so that they will bear a proportionate share of the cost commensurate with the benefits that will accrue to them.

The estimated average annual cost of operating and maintaining the recommended program is approximately $5,516,100. Of this cost, the Federal Government will expend $112,600; non-Federal public agencies, $187,100; and private interests, $5,216,400. The Federal Government will provide (1) any maintenance of measures installed by it that may be required from the time of completion of such measures to the time of their transfer in good condition to the operating and maintaining agency, (2) operation and maintenance of measures installed on Federal land, (3) one-half of the cost of maintaining adequate fire control on non-Federally owned woodland, and (4) one-half the cost of technical services necessary for maintenance of woodland improvement and management practices on privately-owned woodland.

The estimated cost of installing the recommended program in the Roanoke River Watershed is shown in table 2.

Table 2.--Estimated cost of installing the recommended program in the Roanoke River Watershed

Item	Unit	Approximate number	Cost (1946 prices)
			dollars
Subwatershed waterways	Miles	420	681,100
Gully stabilization and sediment control	Miles	780	356,800
Erosion control along roads and railroads	Miles	4,799	666,000
Diversion channels	Miles	488	70,300
Terraces	Miles	46,180	3,304,800
Field border plantings	Acres	6,060	251,300
Farm waterways	Acres	22,880	1,451,800
Mountain watercourse control	Miles	38	404,400
Adequate fire control	Acres	662,300	463,600
Woodland management	Acres	2,356,000	4,177,400
Tree planting	Acres	147,200	2,702,300
Land acquisition	Acres	70,000	476,000
Tributary channel improvement and streambank stabilization	Miles	2,782	3,551,700
Total			18,557,500

The costs of technical services, educational assistance and administration of direct aids are included in above costs and amount to approximately 27 percent of the total cost. Non-Federal public agencies will bear one-half the cost of technical services on privately-owned woodland and one-half the cost of educational assistance.

BENEFITS FROM THE RECOMMENDED PROGRAM

The principal benefits that will result from carrying out the recommended program are reductions in floodwater damage, reductions in sediment and land damages, increased productivity of bottom lands, and associated benefits such as open land conservation benefits, woodland benefits, and decreased maintenance costs on public roads and railroads (table 3).

Benefits from Reductions in Floodwater Damage

The effect of the recommended practices and measures will be to reduce significantly many small floods which, considered collectively, inundate relatively large areas frequently. The medium sized floods will be modified considerably thereby further decreasing the extent and frequency of flooding. The benefit resulting from reducing floodwater damage to agriculture makes up 54 percent of the estimated total average annual flood control benefit and most of it will accrue along the tributary streams. Benefits will also accrue to industrial, commercial, residential, utility, highway, and railroad properties. The recommended program, when installed in proper combination and sequence and adequately maintained, will reduce all present floodwater damages by an estimated 14 percent. These benefits will begin soon after installation of the recommended practices and measures.

Benefits from Reductions in Sediment and Land Damages

Benefits resulting from the reduction of sediment and related damages are of three principal kinds; reduction in reservoir sedimentation, reduction in water treatment costs, and reduction in land damages.

Benefits accruing from reducing the rate of storage loss and the consequent increase in the useful life of reservoirs were evaluated for all important reservoirs. The reservoirs range in size from small, channel type structures to Buggs Island Reservoir with a storage capacity of nearly 3,000,000 acre-feet now under construction by the Corps of Engineers. Many reservoirs have already filled with sediment or are rapidly approaching the limit of their usefulness. The recommended program, if carried out, will result in appreciable benefits to 8 reservoirs. The average annual sediment damage to existing reservoirs and reservoirs now under construction will be reduced by an estimated 15 percent.

Most of the water supply for public and industrial use comes from surface sources and is treated before use. The recommended program will reduce the sediment content of the water and thereby will decrease filtering and other costs of water treatment by an estimated 3 percent.

Sediment and related damages to land are classified as deposition of infertile materials, swamping, and scouring or washing away of the flood plain surface. These damages will be reduced by the soil and water conservation practices on the land, and by channel improvement and stabilization works which will cut down the movement and deposition of sand, improve drainage conditions by lowering the water table in swampy areas, and reduce scour by reducing the frequency of overbank flows.

The recommended program will reduce land damages caused by sanding, swamping, and scour by an estimated 13 percent.

Benefits accruing from all reductions of sediment and related damages described above are estimated to be 7 percent of the total average annual flood control benefit.

Benefits from Increased Productivity of Bottom Lands

The recommended channel measures and associated works of improvement for controlling runoff will not only prevent swamping and reduce flood damages but will also permit the drainage of fertile bottom lands by landowners and operators. Much of this land has a high capability for producing excellent yields of cultivated crops. Lands of lower capability when properly protected against floods and drained will produce moderate returns from hay and pasture. Approximately 57,200 acres of bottom land will be benefited from the recommended program.

Associated Benefits

Other benefits evaluated in this report that will accrue from the installation of the recommended practices and measures include open land conservation benefits, woodland benefits, and decreased maintenance costs on public roads and railroads.

The open land conservation benefits evaluated in monetary terms consist of the direct benefits that will accrue to participating landowners and operators through decreases in farm operating costs and increases in farm income.

The woodland benefits were derived from a determination of yields with and without the recommended program. It is expected that under proper management the forest stands will be brought into full stocking. This will be accomplished by planting trees, providing

adequate fire control, restricting the periodic cut to a portion of the annual growth until the stand is fully stocked, and other watershed woodland management practices. Comparative incomes on the basis of present conditions and conditions with the recommended program installed were used to estimate the average annual benefit of the woodland measures.

Eroded material washed down from unprotected roadway and railroad cuts and fills obstructs ditches and culverts. About one-third of the total cost of roadway maintenance is chargeable to the removal of this material. Eventually some of this eroded material causes damage to flood plains and reservoirs. Highway maintenance figures from areas already treated indicate that roadway treatment to stabilize cuts and fills and roadway ditches reduces maintenance costs by approximately 66 percent. The cost of maintenance operations along railroad-rights-of-way also will be substantially reduced by stabilization measures for orderly disposal of storm runoff and control of erosion.

Comparison of Benefits and Costs

Based on prices and costs expected to prevail under high employment levels and discounted for delayed costs and benefits, the ratio of the average annual benefit to the average annual cost of the recommended program is 2.11 to 1.

Table 3.--Estimated average annual monetary benefit from the recommended program for the Roanoke River Watershed 1/

Source		Average annual benefit (1946 prices)
		dollars
Reductions in Floodwater Damage		
Agricultural - crop and pasture	254,200	
Non-agricultural - roads and railroads	8,600	
Sub-total		262,800
Reductions in Sediment and Land Damages		
Reservoir sedimentation	13,200	
Water treatment costs	11,100	
Land damage (sanding, swamping, and scour)	9,100	
Sub-total		33,400
Increased Productivity of Bottom Land	177,800	177,800
Total average annual flood control benefit		474,000
Associated Benefits		
Open land conservation benefit	8,512,100	
Woodland benefit	6,409,600	
Decreased maintenance costs on public roads and railroads	232,000	
Sub-total		15,153,700
Total average annual benefit		15,627,700

1/ In addition to this benefit, other unevaluated benefits will accrue. The most important benefits of this type are the prevention of loss of life, prevention of interruptions in transportation and communications, improvement of wildlife habitat, preservation of aesthetic values, and improvement of the economic and social structure of the watershed area.

Revised May 1952

SURVEY REPORT

(APPENDIXES)

ROANOKE RIVER WATERSHED

VIRGINIA · NORTH CAROLINA

program for runoff and waterflow retardation - and soil erosion prevention

U. S. DEPARTMENT OF AGRICULTURE

~~SEPTEMBER 1950~~
JULY 1951

NOTE

Certain discrepancies exist between the report and these appendixes in connection with the acreage to be treated by forest land measures, the cost of such measures, the benefits to be derived from them, and the benefit-cost ratio of the recommended program. Details concerning these discrepancies are shown on page 37, Appendix D.

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APPENDIX A

PHYSICAL FACTORS

ROANOKE RIVER WATERSHED

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DESCRIPTION

General

The Roanoke River Watershed, in Virginia and North Carolina, has a total area of 9,580 square miles. The headwater area is in the valley and ridge section west of Roanoke, Virginia. It flows southeastward approximately 200 miles to Clarksville, Virginia, where it is joined by the Dan River, its principal tributary. The river crosses into North Carolina 38 miles below Clarksville and crosses the Fall Zone along a ten mile reach which begins 24 miles below the state line and ends at Weldon, North Carolina. Here the river enters the Coastal Plain and flows generally southeastward along a 125 mile meandering course to Batchelor Bay at the western end of Albemarle Sound.

The Dan River above its confluence with the Roanoke has a watershed area of 3,855 square miles. Above the same point the Roanoke River has a watershed area of 3,465 square miles. The Dan has its origin near Meadows of Dan, Virginia, on the eastern side of the Blue Ridge 10 airline miles northwest of Stuart, Virginia. It flows southeastward to Walnut Cove, North Carolina, and there turns northeastward and flows in this general direction to Clarksville, Virginia, where it joins the Roanoke River. Total length of the Dan River is about 210 miles.

The entire Roanoke River Watershed has been divided into four physical land units in order to develop and evaluate the recommended program. These are major separations, made on the basis of similarities with respect to vegetative cover, soils, geology, and stream characteristics. These are important factors which influence runoff and flood control. Figure A-1 is a map of the watershed showing the physical land units. They are described briefly below.

Limestone Valley

The Limestone Valley physical land unit comprises 4-1/2 percent of the watershed area. It lies between the Appalachian Ridges on the northwest and the Blue Ridge Mountains on the southeast. The Roanoke River and its tributaries are here entrenched and have cut down below the valley floor or lowest and youngest peneplain. This is a level or undulatory surface underlain by limestone and shale, about 1,000 feet above sea level. In the vicinity of Roanoke, Virginia, depth of entrenchment of the river and its main tributaries is 50 to 100 feet below the valley floor peneplain. The sandstone mountain ridge area northwest of the Limestone Valley is included with this physical land unit for purposes of evaluation because of its limited area. Throughout the unit, stream gradients are generally high, flood plains are comparatively narrow and flood damages limited in extent. The area is 46 percent wooded.

Mountain-Foothills

The Mountain-Foothills physical land unit comprises 18-1/2 percent of the entire watershed. It consists of the Blue Ridge Mountains and its eastern foothills. It is bounded on the northwest by the Limestone Valley, from which it is separated by the sinuous Blue Ridge Fault, and on the southeast by the Piedmont Plateau. The underlying rock is crystalline except for comparatively small areas of sedimentary rocks along the aforementioned Fault. The streams have high gradients and the flood plains are narrow and poorly developed. Soils range from thin mountain soils to foothill soils, some of which are similar to but not as well developed as those on the Piedmont Plateau. Nearly 69 percent of this area is in woodland.

Piedmont Plateau

The Piedmont Plateau includes the Crystalline Rock Portion, 49-1/2 percent; Triassic Belt, 4-1/2 percent; and "Slate" Belt, 10 percent; or considered as one physical land unit, it includes 64 percent of the Roanoke River Watershed. The western border of the plateau is an irregular line with the steeper, more highly dissected foothills at an average elevation of 800 feet. The plateau is an upland, a remnant of a former peneplain, into which the Roanoke River and its tributary streams have incised their channels. Rolling to steep hills have been formed by normal geologic erosion. The surface of the plateau has an average southeastward slope from the foothills to the Fall Zone of about 7 feet per mile. Along the Fall Zone the plateau rocks pass beneath the Coastal Plain sediments at an elevation of about 100 feet above sea level.

Approximately 53 percent of the Piedmont Plateau is wooded.

Coastal Plain

The Coastal Plain comprises 13 percent of the total watershed area. It consists of unconsolidated and semi-consolidated sands, clays, and marls, thin at the western margin, but gradually increasing in total thickness eastward and attaining thicknesses of several thousand feet. Beneath these sediments lie the eastward extension of the igneous and metamorphic rock mass of the Piedmont Plateau. The surface topography of the Coastal Plain is flat to gently rolling, with limited steeply rolling areas along the Fall Zone. About 69 percent of the area is in woodland. Flood plains are wide and well developed, and stream gradients are low. The land inundated by extreme floods along the Roanoke River ranges from 3 to 5 miles in width between Weldon, North Carolina and Batchelor Bay.

The following table gives the distribution of physical land units by states.

Distribution of physical land units by states

Physical land unit	Virginia	North Carolina	Total
	Acres		
Limestone Valley	277,030	--	277,030
Mountain-Foothills	972,008	163,090	1,135,098
Piedmont Plateau	2,693,362	1,239,360	3,932,722
Coastal Plain	--	786,350	786,350
Grand total	3,942,400	2,188,800	6,131,200
	Sq. Miles		
	6,160	3,420	9,580

PRESENT LAND USE CONDITIONS

Approximately 57 percent of the Roanoke River Watershed is in woodland, 19 percent is in cropland, 7 percent pasture, 6 percent idle land, and 11 percent miscellaneous. Seventy-one percent of the watershed area is in farms and 29 percent is not in farms. The non-farm land is largely in woods. Woodland makes up 52 percent of the farm acreage. Twenty-six percent of the land in farms is cropland, 10 percent pasture, 9 percent idle, and 3 percent miscellaneous. The principal row crops are corn, tobacco, peanuts, and cotton. Wheat is the principal small grain. Pastures make up about one-third of the farm land in the Limestone Valley, but only one-fifteenth in the Coastal Plain where open range woodlands are grazed. With the exception of the upper portions of the watershed, pastures are generally overgrazed and badly in need of improvement. Most of the cultivated area is without cover crop protection during the winter months. Erosion of these unprotected fields adds to the runoff and sedimentation problem.

The Coastal Plain area contains about 15 percent, or 540,850 acres, of the total woodland area of the watershed. This section, located in the lower part of the watershed, has comparatively level topography, and soils are chiefly deep light sandy loams and sands. Under such conditions runoff is slow and erosion moderate. An accelerated woodland program cannot be justified in this area on the basis of flood control benefits.

LAND USE CAPABILITIES

Measured data of soil conservation surveys, made by the Soil Conservation Service in the Roanoke River Watershed, were used for determination of the land use capabilities within the watershed.

After a careful study, these sample areas were expanded to areas for which the individual samples are representative.

Table A-1 is a summary of the distribution of land use capability classes by present land use.

RUNOFF

Under present land use conditions, runoff has been accelerated throughout the greater portion of the watershed. The infiltration rate and water storage capacity of the original soils have been decreased generally.

In order to consider how conversions of land use would be effective in reductions of runoff, changes to be made are listed in six broad categories as follow:

(1) The remedial program would provide for the conversion of the larger portion of woodland in hydrologic condition classes II and III to hydrologic condition class I. Woodland in hydrologic condition class I will be maintained as such (see table A-4). A small portion of the woodland occurs on soils of very low infiltration rates. These low rates may represent the natural condition of the soil or be the result of severe sheet erosion or other land misuse. Even under the best of management, the infiltration rates on these areas can be increased only slightly.

(2) All idle land would be used for cropland, pasture, woodland, for perennial vegetation or for wildlife refuge and cover, according to its land use capability and needs.

(3) All cropland of land capability classes I and II, and part of III and IV, will be retained as cropland. Soil conservation practices such as improved rotations, permanent vegetative strips and properly built terraces, along with contour cultivation, will result in improved hydrologic condition of the land retained as cropland.

(4) A part of land capability classes III and IV now in cropland and nearly all land of classes VI and VII now in cropland will be used as pasture, woodland, for perennial vegetation, or for wildlife refuge and cover.

(5) Pasture improvement and management will improve the water retention capacity of pastured areas, thereby reducing runoff.

(6) Miscellaneous areas consist of farm homesites, urban areas, lakes, stream channels, roadways and

railways. Stabilization of drainageways, cuts and fills along roadways and railways is recommended. There will be little or no reduction of runoff in miscellaneous areas such as farm homesites and urban areas.

Infiltration Formula Method

The infiltration formula method, which is based on data covering areas scattered over the entire United States, represents average conditions for the entire country. This has been devised to develop a simplified method to determine the effect of improved soil and cover conditions on runoff.

In applying this method, it is necessary to have basic information of soil and cover conditions for the watershed on which runoff determinations are to be made. Data were assembled, first, to show the distribution of soil textural groups by cover under existing land use conditions; and, second, to show the distribution of soil textural groups by cover after the remedial land use program is in full effect. The textural groups are based on field determination and/or mechanical analysis of sand, silt and clay fractions. This is taken from tabulated data, published or unpublished, for areas where soil surveys have been made. This classification is solely for use in the infiltration formula and may group soils not similar in other respects. The extent of distribution of each group was based on measured soil conservation surveys or other type of measured soil surveys. The present cover distribution was based on soil conservation surveys, soil conservation district reports, and the U. S. Census of Agriculture. Future cover conditions, after the remedial flood control program is in full effect, were based on the best conservation measures for the land as indicated by the land use capabilities and economic factors involved.

EROSION

Accelerated erosion is most severe in the Piedmont Plateau and the foothills portion of the Mountain-Foothills. It is also a serious problem in the Limestone Valley and in the upper portion of the Coastal Plain.

The most severely eroded upland areas are not necessarily the source of sediment causing the greatest damage to flood plains. Permanent damage to bottom lands often occurs if the upland removals are sand, gravel, or coarser grained sediment. If these materials reach the stream channel and become bed load, channel capacity is thereby reduced. The result is a rise in the stream water level and the water table within the alluvial soils that comprise the contiguous bottom lands. This process in its ultimate phases causes swamping of once productive bottom lands. Another type of damage by coarse erosional debris occurs where splays are deposited on bottom lands, or fertile soils are scoured, during floods.

Although the coarser erosional debris is responsible for the greater portion of the permanent land damage, the finer materials cause serious damage of a different nature. Forage plants are rendered unpalatable, temporarily, by deposition of fine material on their foliage. High turbidities, the result of fine material in suspension, increase filtration costs of municipal water supplies. The latter may also be harmful to fish or other aquatic life.

Table A-2 shows the distribution of land by generalized erosion conditions, which conform to those in "Guide for Soil Conservation Surveys", May 1, 1948.

Sheet Erosion

Sheet erosion occurs where surface water flowing downhill removes surface soil by thin layers. In areas where the original surface layer of the upland soils is fine grained, such as the silt loams and loams, sheet erosion may have caused damage to upland fields; but that portion of the topsoil removals, which is later deposited on alluvial lands, may be as fertile as the soil on which it is deposited. In areas where the surface soil is high in sand and gravel content, removal by sheet erosion contributes to stream channel fill and deposition of sterile material on fertile flood plains.

The original surface soils in the Roanoke River Watershed above the Fall Zone were predominantly fine sandy loams and silt loams. Where upland surface soils of these textures have been removed, the subsoils, clays, clay loams, and silty clay loams have been exposed. The greatest damage due to sedimentation has resulted in the Piedmont Plateau, where sand and coarser grained sediment have been removed from the uplands and deposited on fertile bottom land soils.

Gully Erosion

On the basis of conservation survey data, it is estimated that in the entire watershed there are 289,000 acres of land with occasional deep gullies (3 or less per acre), 49,500 acres of land with frequent deep gullies (3 or more per acre but less than 75 percent of the area in gullies), and 4,800 acres of land in which more than 75 percent of the area is gullied. The most seriously gullied area is in the crystalline portion of the Piedmont Plateau and the foothills portion of the Mountain-Foothills. Here, gullies developed upon quartz-rich acidic rocks which underlie the Cecil and Hayesville soil series are the chief sources of sterile sands and gravels.

Erosion on Forest Land

Erosion on forest land most often results from poor logging practices or from grazing by domestic livestock. On forested slopes

that have been logged by "up and downhill" skidding methods, erosion is a common occurrence. As demonstrated by studies at the Coweta Experimental Forest, even though the area actually occupied by roads and skid trails was small compared with the total area, surface runoff and sediment production was greatly accelerated. A sloping area logged in this manner and not treated for erosion control after logging showed sediment production greater than that of a similar watershed area cleared and poorly farmed. Also, when livestock grazing had been permitted within a woodland area, soil compaction resulted in active erosion as well as in decreased infiltration capacity as shown by character of surface runoff.

Roadway and Railroads

Roadway and railway cuts, fills, and drainageways which have not been stabilized constitute another important source of erosional debris. This is particularly true of unimproved roads in the Piedmont Plateau and Foothills. Here roadside cuts, fills, and drainageways are generally unprotected and seriously eroded. Some abandoned road sites have been reduced to one large gully at the site of the old roadway.

CLASSIFICATION AND DETERMINATION OF FOREST LAND HYDROLOGIC CONDITION

Factors Determining Hydrologic Condition

The ability of forest soils to absorb and store water is governed primarily by the structure of the soils. Soil structure, in turn, is greatly influenced by the nature and condition of the forest cover and by forest land treatments such as logging, fire, and grazing which affect directly both soil and cover. Optimum conditions for infiltration of water into the soil are created when a sufficient protective soil cover is present to prevent puddling and sealing of the soil surface; when a humus layer is present and is sufficiently deep to retain all of the water delivered by short bursts of high intensity rainfall and to release the water slowly to the soil surface; when the soil is loose and friable--a condition directly related to the amount of organic material in the soil; and when maximum amounts of earthworm and tree root activity are present to loosen the soil and to provide channels for percolation of water deep into the soil. All of these conditions are found to a high degree under thrifty and reasonably well stocked stands of timber. They are found to a much smaller degree under poorly stocked stands.

Severe opening or removal of the tree cover brings about a chain reaction. Increased exposure of the forest floor to sun and wind increases the rate of oxidation of the humus layer. The organic material which might otherwise go into the soil is dissipated into the air. Fewer trees deposit less litter to make up the humus deficiency. With the resulting exposure of the soil surface puddling and rain drop erosion increase, the surface is sealed off,

and infiltration rates rapidly decrease. Fewer trees provide fewer root channels for deep penetration of the water and the upper layers of the soil become saturated more rapidly.

In addition to their detrimental effect on the tree cover itself, poor logging practices have a deteriorating effect on soil-water relationships. Logging skid roads, poorly located and without adequate water spreading devices, hasten runoff, cause erosion, decrease soil moisture, and reduce the amount of water infiltrated into the forest floor.

Both fire and grazing by domestic animals lower the hydrologic condition of forest soils. Fire removes much of the forest floor and may kill much of the tree cover. Grazing compacts the soils and creates conditions less favorable for high rates of infiltration.

Classification of Forest Land Hydrologic Condition

Since the infiltration capacity of forest soil is related to forest floor conditions and forest floor conditions are in turn related to character and amount of forest cover, the hydrologic condition of forest land may be partially classified on the basis of character and amount of forest cover. Study of infiltration capacities under various forest-cover complexes revealed that hydrologic condition was related to forest cover about as follows:

Hydrologic condition class I.--Includes forest land characterized by optimum opportunity for infiltration. Such conditions are found under thrifty stands reasonably well stocked with timber. These stands are undisturbed by grazing and fire and are either in nonoperating status or are being operated for timber production in accordance with good timber and watershed management.

Hydrologic condition class II.--Includes forest land characterized by intermediate opportunity for infiltration. This is found under stagnated stands or under stands of poor to medium stocking with timber. Such stands are undisturbed by grazing and fire. Logging operations, when present, are usually more intensive than in class I. The soil under such stands is usually somewhat compacted and the humus layer is usually thin or only partially developed.

Hydrologic condition class III.--Includes forest land characterized by poor opportunity for infiltration. It is generally found on denuded or poorly-stocked forest land whether heavily burned, grazed, or not. It is found on all forest land regardless of surviving timber cover when heavily burned or grazed. Forest soils are distinctly compacted with but a thin compact humus present.

Determination of Present Distribution of Forest Land Hydrologic Condition Classes

Since forest stand condition, thrift, and land use are all directly related to woodland hydrologic condition it was possible to make use of Forest Survey data describing the areal extent of forest land by stand condition classes as a partial basis for determining the distribution of hydrologic conditions within the forest area. This information was supplemented by the flood control survey organization with field studies of hydrologic conditions under various forest stand conditions and with information obtained from the soil conservation districts regarding the extent of grazing in farm woodland.

Future Hydrologic Condition of Forest Land

The determination of the future hydrologic condition of forest areas unaffected by fire and grazing was based on the hydrologic condition of existing woodland where stand conditions are comparable to those that will be attained with the recommended program. In other words, it was assumed that with good forest land management the future woodland will attain a hydrologic condition comparable to that currently existing under reasonably well stocked, ungrazed, unburned stands.

In accordance with the plan of improvement discussed in Appendix E, the average annual burn will be reduced to 1/10 of one percent on all woodland, and livestock grazing will be largely eliminated. Management plans will be designed and carried out to assure good watershed management. The objective will be to create good hydrologic conditions by building up and maintaining thrifty reasonably well stocked stands.

Because of abandonment and low capability for agricultural use, 181,300 acres of open land, now without adequate cover, are scheduled for conversion to forest land (table E-1). Conversion will improve the hydrologic condition of these lands and will raise the total forest land area after the program is installed to 3,695,647 acres.

The expected future hydrologic conditions are shown in table A-3.

Effect of Prescribed Burning on Future Hydrologic Conditions

Present and expected economic conditions indicate the desirability of maintaining pine stands on as much of the Coastal Plain Land Unit as possible. Of the many methods which have been investigated to promote the regeneration of pine in this area, prescribed burning has proved to be one of the more feasible. Due to the particular soil and topographic conditions found in the Coastal Plain, prescribed burning has little if any adverse effect on watershed values.

CLIMATE

The climate of the Roanoke River basin is temperate. Average monthly temperatures vary from approximately 40° during December and January to 75° - 80° during June and July. The maximum temperature recorded at Weldon, N. C., gage is 107°, the minimum 9°. The average length of the growing season varies from 207 days in the Coastal Plain to 180 days in the mountains. The Coastal Plain has high humidities during the summer months.

Light snow and freezing temperatures occur annually in the western portion and occasionally over the entire watershed. The average annual snowfall varies from 8.2 inches at Weldon, N. C., to 19.4 inches at Clarksville, Virginia. Snow is seldom if ever an important contributing factor to flood flows in the Roanoke basin. Frozen ground is usually of short duration and not deep enough to cause any important increase in runoff. Under certain conditions it may add considerably to soil erosion and sedimentation. Occasionally ice occurs on the Roanoke River. On rare occasions, it may last for several days and be of considerable thickness. There are no records of ice jams contributing to flood damage.

Precipitation is well distributed throughout the year with slightly more rainfall and greater intensities during the summer months. The heaviest rainfall occurs over the Coastal Plain section and on the eastern slope of the Blue Ridge Mountains. Mean annual precipitation for the basin is approximately 43 inches varying from a minimum of 41 inches at Roanoke, Virginia, to 60 inches at Pinnacles, Virginia. Williamston, North Carolina, in the Coastal Plain has 49 inches.

Flood producing storms may occur at any time during the year. They are of three general types.

(1) Winter warm-front rains cause about 50 percent of the floods at Weldon, North Carolina. They cover large areas and are usually of low intensity but of several days duration. The largest streams reach high stages and remain out of their banks for several days. The small streams generally do not exceed bank full stages.

(2) About 30 percent of the floods is caused by summer convection type storms. Usually only a relatively small area is affected. They include thunderstorms and occur from April to July. Rains of high intensity and short duration are produced which cause extreme floods on the tributaries, but ordinarily have little effect on the main streams.

(3) The late summer and fall storms are usually accompanied by torrential rains over large areas. They are often associated with tropical hurricanes. About 20 percent of the floods, including the largest floods of record, is produced by storms of this type. The general effect of these storms is widespread but spotty. High

stages invariably occur on main streams, with disastrous floods on many of the tributaries. Some of the tributaries may be affected very little. Because of the season of their occurrence, they produce the most extensive crop damage. Winter storms of unusual intensity or summer storms of a general nature are of rare occurrence, but are capable of producing floods of extreme size over large areas.

Table A-1

NIT

Land Capability Class and Subclass 1/		Limestone Vall... Land Use (Ac... Crop-land	Wood-land	Idle-land		Coastal Plain Land Use (Acres) Crop-land	Wood-land	Idle-land	Pasture	Sub-Total	Total (Acres)
I		1985	1602	269		39792	16710	361	3246	60109	232122
II	e	8796	5473	1737		36781	145729	3485	10457	196452	885360
	w	4099	4311	344		19843	78620	1880	5642	105985	123249
	s					10674	42293	1012	3035	57014	57014
III	e	22120	29575	4129	1	4766	11840	535	2446	19587	1454621
	w	2541	5481	424		9775	87023	882	4893	102573	148879
	s					7952	31505	753	2261	42471	42471
IV	e	6521	25478	2690	1	150	4131	30	234	4545	748129
	w					310	2262	611	37	3220	4203
V	w	188	1496	34		712	89080	547	746	91085	268297
VI	e	1982	19584	1062		154	12467	307	82	13010	359203
	s					442	17053	353	264	18112	18112
VII	e	2708	34433	3007		31	1266	18	546	1861	1120435
	s						871	91	72	1034	1034
VIII	s										4459
Sub-Total		50940	127433	13696	4	31382	540850	10865	33961	717058	5467588
Misc. 2/										69292	663612
Total Area										786350	6131200

1/ Definition of Subclasses: e - Do
w - Do
s - Do
vey,

2/ Includes farm home sites, urban a

Table A-1

DISTRIBUTION OF LAND IN THE ROANOKE RIVER WATERSHED
SHOWING PRESENT LAND USE BY CAPABILITY CLASSES WITHIN EACH PHYSICAL LAND UNIT

Land Capability Class and Subclass 1/		Limestone Valley Land Use (Acres)					Mountain-Foothills Land Use (Acres)					Piedmont Plateau (Land Use (Acres)					Coastal Plain Land Use (Acres)					Total (Acres)
		Crop-land	Wood-land	Idle-land	Pasture	Sub-Total	Crop-land	Wood-land	Idle-land	Pasture	Sub-Total	Crop-land	Wood-land	Idle-land	Pasture	Sub-Total	Crop-land	Wood-land	Idle-land	Pasture	Sub-Total	
I		1985	1602	269	329	4185	28958	6822	3138	4448	43366	27655	64955	4416	27436	124462	39792	16710	361	3246	60109	232122
II	e	8796	5473	1737	2276	18282	17775	40086	2458	3515	63834	171409	357647	36599	41137	606792	36781	145729	3485	10457	196452	885360
	w	4099	4311	344	1365	10119	952	153	86	944	2135	673	3772	36	529	5010	19843	78620	1880	5642	105985	123249
	s																10674	42293	1012	3035	57014	57014
III	e	22120	29575	4129	15417	71241	56654	101785	10243	9110	177792	452073	579443	105349	49136	1186001	4766	11840	535	2446	19587	1454621
	w	2541	5481	424	1773	10219	2856	19	42	201	3118	2724	17162	3772	9311	32969	9775	87023	882	4893	102573	148879
	s																7952	31505	753	2261	42471	42471
IV	e	6521	25478	2690	18268	52957	22511	65672	7461	21298	116942	98838	390634	64427	19786	573685	150	4131	30	234	4545	748129
	w						73	459		274	806		177			177	310	2262	611	37	3220	4203
V	w	188	1496	34	150	1868	1077	5416	543	565	7601	25084	94103	15796	32760	167743	712	89080	547	746	91085	268297
VI	e	1982	19584	1062	4644	27272	5188	143592	2920	8105	159805	9568	135608	6580	7360	159116	154	12467	307	82	13010	359203
	s																442	17053	353	264	18112	18112
VII	e	2708	34433	3007	4725	44873	13958	414836	13931	30080	472805	30103	422768	77751	70274	600896	31	1266	18	546	1861	1120435
	s																	871	91	72	1034	1034
VIII	s							547	71	3025	3643	51	688	31	46	816						4459
Sub-Total		50940	127433	13696	48947	241016	150002	779387	40893	81565	1051847	818178	2066957	314757	257775	3457667	131382	540850	10865	33961	717058	5467588
Misc. 2/						36014					83251					475055					69292	663612
Total Area						277030					1135098					3932722					786350	6131200

1/ Definition of Subclasses: e - Dominant limitation is susceptibility to erosion by water.
w - Dominant limitation is excess water, such as that produced by seepage, high water table, or floods.
s - Dominant limitation is an outstandingly unfavorable soil characteristic, such as low moisture capacity, very high density (imperviousness), excess gravel or stones, shallow effective depth, etc.

2/ Includes farm home sites, urban areas, lakes, stream channels, roadways, and railways.

Table A-2

DISTRIBUTION OF LAND BY GENERAL EROSION CONDITIONS
ROANOKE RIVER WATERSHED

Physical Land Units	Degree of Accelerated Erosion 1/					Total
	No Apparent or Slight	Moderate	Severe	Very Severe	Very Severely Gullied Land 2/	
	Acres	Acres	Acres	Acres	Acres	Acres
Limestone Valley	86,828	176,933	9,478	3,338	453	277,030
Mountain-Foothills	496,826	467,666	139,284	25,365	5,957	1,135,098
Piedmont Plateau	879,040	1,094,316	1,112,202	799,423	47,741	3,932,722
Coastal Plain	689,637	93,861	2,479	224	149	786,350
Total	2,152,331	1,832,776	1,263,443	828,350	54,300	6,131,200

9,580 sq.m

1/ Moderate, Severe, and Very Severe Erosion Areas include 289,000 acres of land, with occasional deep gullies (3 or less per acre).

2/ Very severely gullied Land includes 49,500 acres of land with frequent deep gullies, (3 or more per acre), and 4,800 acres of land in which more than 75 percent of the area is gullied.

Table A-3.--Hydrologic condition of woodland in the Roanoke River Watershed

Physical Land Unit	Present				Future			
	I	II	III	Total	I	II	III	Total
	acres	acres	acres	acres	acres	acres	acres	acres
Limestone Valley	10,195	30,584	86,654	127,433	106,856	14,175	11,357	132,388
Mountain-Foothills	70,145	202,641	506,601	779,387	676,440	68,922	61,298	806,660
Piedmont Plateau	186,026	392,722	1,488,209	2,066,957	1,854,574	199,664	161,511	2,215,749
Coastal Plain	59,494	81,127	400,229	540,850	59,494	81,127	400,229	540,850
Watershed Total Acres	325,860	707,074	2,481,693	3,514,627	2,697,364	363,888	634,395	3,695,647
Percent of Watershed	9	20	71	100	82	10	8	100

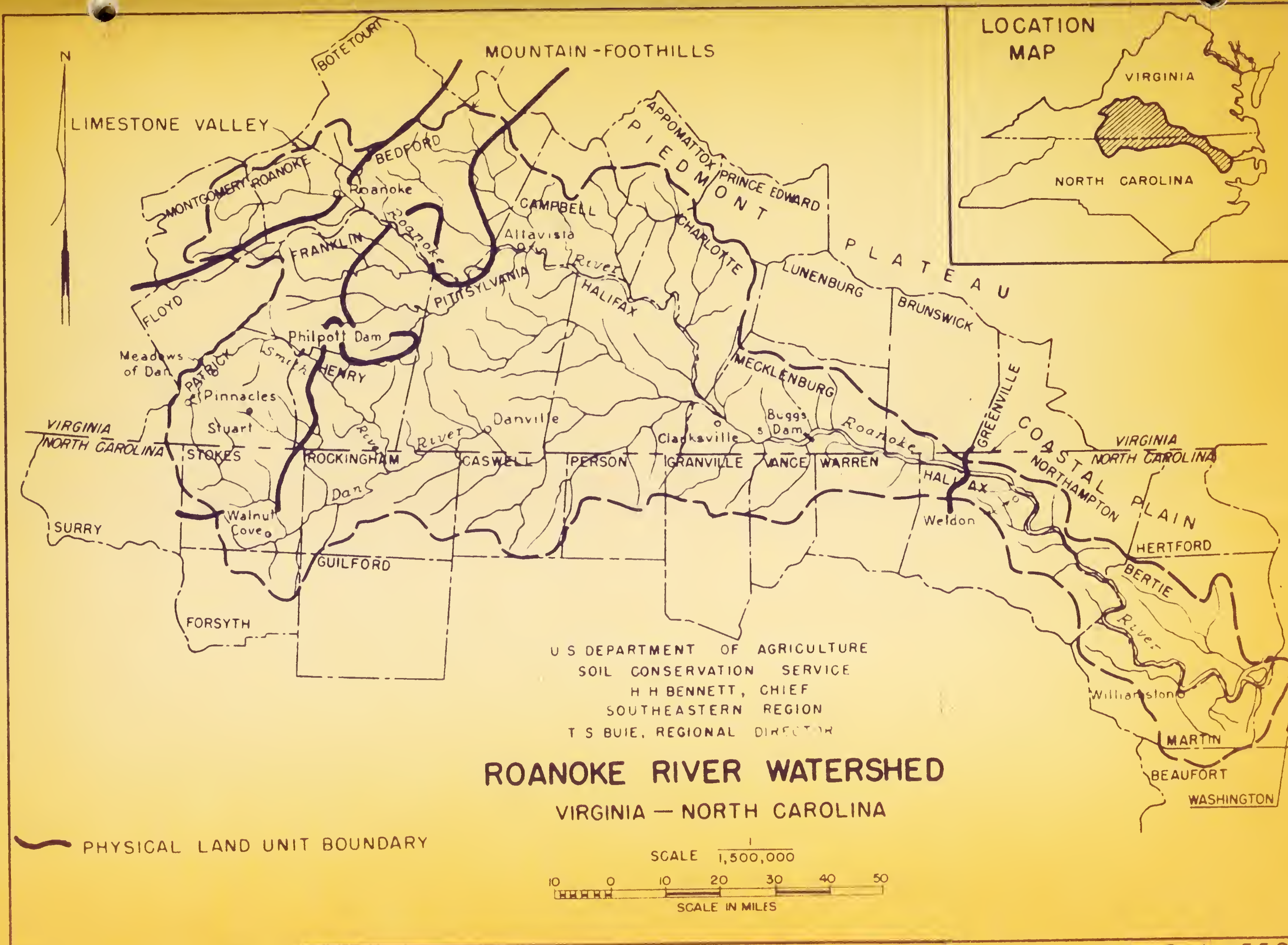

FIGURE A-1

2-L-5509-D

AREA AND POPULATION

Four entire counties and parts of 27 other counties in the states of Virginia and North Carolina are within the Roanoke River Watershed, most of which will be directly affected by the recommended program. The total land area within the watershed is approximately 6,131,200 acres. The total population of the Roanoke River Basin is estimated at 663,000, of which 433,000 are located in Virginia and 230,000 in North Carolina. The 1940 census indicates approximately 74 percent of the total population was rural, and about 50 percent was rural farm. According to House Document No. 650 dated June 6, 1944, the rural farm population of the watershed in 1930 represented 56 percent of the total, with little change to 1935. However, by 1940 there was an apparent downward trend in the farm population in relation to the total population of the watershed.

The urban centers within the watershed are principally small with only seven incorporated cities and towns having populations of 5,000 or more in 1940. Of these, four have populations exceeding 10,000 and two have populations in excess of 25,000. Roanoke and Danville, Virginia, are the only two cities in the watershed with populations of over 25,000.

Initial settlement of the watershed was along the major streams. Six of the seven cities having populations exceeding 5,000 are located along the main stems of the Roanoke, Dan, and Smith Rivers. The city of Roanoke, Virginia, located along the headwaters of the Roanoke River is the largest of these cities, having a population of approximately 69,000 in 1940.

AGRICULTURAL RESOURCES

Agriculture now accounts for about 56 percent of the occupational activity of the region. The principal cash crops, for the watershed as a whole, are tobacco, peanuts, and cotton. Recent trends throughout the watershed are toward greater emphasis on the various livestock enterprises, particularly dairy products and beef cattle. The present estimated average annual gross value of farm crops in the basin (based on 1946 farm prices) is approximately $139,000,000 (excluding the gross value of farm woodland products and vegetables for home use). The total value of the three major cash crops amounts to approximately 70 percent of the gross value of all farm crops. Tobacco alone amounts to 60 percent of the gross value.

Farm practices and the chief sources of farm income vary considerably within the different Physical Land Units. In the Limestone Valley, the most important sources of income are truck crops and fruits, with the dairy enterprises assuming a major role in the production of cash. In the Mountain-Foothills, tobacco is the major cash crop, but poultry products, vegetables, fruit crops, dairying and beef cattle are also important sources of cash income. In the Piedmont Plateau, tobacco amounts to 90 percent of the gross cash crop income while the revenue

from cotton, truck crops, fruits, and livestock enterprises is relatively unimportant. In the Coastal Plain, tobacco, peanuts, and cotton are the most important sources of farm income, with tobacco and peanuts (including peanut hay) about equal in value. The revenue from cotton amounts to about 20 percent of the total value of the three crops.

The prevailing practices in the watershed have been to cultivate the highly productive soils of the flood plains and the uplands. In the mountainous sections, a comparatively large proportion of the land suitable for cultivation lies within the flood plains of the various streams. Despite the flood hazard, a high percent of these flood plain lands is still planted to corn, hay, small grain, rotation or temporary pasture, and a small acreage of tobacco. In the other portions of the watershed, the flood plain lands have gradually reverted to poor quality pasture or woodland. This is due to poor quality soils of low fertility resulting from sanding and washing and scouring of the flood plains, and because of the direct flood hazard to crops. Abandoned crop lands are also often found on the better soils which are not seriously damaged by floods. Some of the older farm resident owners of flood plain lands along the tributary streams report that flood plain lands now covered with native growth of trees and other comparatively worthless vegetation were formerly considered the best tobacco land on the farm. Tobacco is still grown by some farmers on the flood plains of these streams in locations less seriously affected by floods. However, the crops most commonly grown on the flood plains of the tributary streams are corn, hay, and pasture. Small grain, truck crops, and occasional plantings of tobacco occupy a small proportion of the land each year.

INDUSTRY

In 1940 there were approximately 500 industrial establishments in the Roanoke River Basin employing about 45,000 people. Roanoke and Danville, Virginia, and Roanoke Rapids, North Carolina, are the most important industrial centers with the principal products being textiles, pulp, paper, rayon, building materials, and furniture.

FARM OWNERSHIP

The pattern and extent of farm ownership in the Roanoke Watershed is such as to indicate encouragement in the establishment of the recommended measures. It is expected that the recommended program will result in appreciable reductions in flood damages on tributary streams. Field contacts and observations indicate that a high percent of the farm owners reside on their farms in the parts of the watershed where the most extensive application of recommended measures will occur.

The watershed treatment program is expected to have the most beneficial effect in reduction of floodwater and sedimentation damages in the Mountain-Foothills and Piedmont Plateau; lesser benefits will result in the Limestone Valley and Coastal Plain. It is assumed that practically all the damages on the Roanoke River floodplain below the Buggs

Island Dam will be eliminated. To date, no appreciable agricultural flood damages have been experienced along the tributary streams in the Coastal Plain.

In 1945, tenancy in the different Physical Land Units varied from 6 percent in the Limestone Valley to 66 percent in the Coastal Plain. In the Piedmont Plateau, 46 percent of the farm operators were tenants, while in the Mountain-Foothills only 21 percent were tenants. From 1940 to 1945, there was an average decline of 4 percent in farm operators, who were tenants, in the entire watershed. However, in the Coastal Plain tenancy increased 5 percent during the same period.

The acreage of farm land operated by tenants in 1945 varies from only 9 percent in the Limestone Valley to 54 percent in the Coastal Plain.

In the Piedmont Plateau, 43 percent was operated by tenants and 18 percent in the Mountain-Foothills. An average of 39 percent of the entire farm acreage of the watershed was operated by tenants in 1945.

The recommended program will have little effect upon ownership or farm tenancy. There are no radical changes recommended in the general type of farming within the watershed. However, the anticipated increased production per unit of land, following establishment of the recommended conservation measures, should materially raise the standard of living for both owners and tenants. Additional benefits will also accrue to both types of operators who make the recommended land use changes. Since these conversions involve chiefly a change in the use of presently idle lands to the production of perennial hays and pasture, it is anticipated that an increase in the value of the various livestock enterprises, particularly dairy and beef cattle, will be realized.

OWNERSHIP OF FOREST LAND

The extent of present forest land ownership is shown in table B-1. Data on Federal holdings were obtained directly from officials of the agencies concerned. The area of forest in farm ownership was derived from the 1945 Agricultural Census. Information on nonfarm holdings was obtained from state forestry officials.

Woodland ownership in the Roanoke River Basin is fairly stable. There is little or no tax delinquent woodland. The area of woodland in farm ownership will be increased slightly by the amount of land converted from agricultural use to woodland.

Public acquisition of woodland is proposed as a flood control measure for woodland which is in poor hydrologic condition and on which the present ownership cannot afford to carry out the proposed improvement measures. Land purchased within an established National Forest will be paid for from Federal funds and be administered as National Forest land. Land purchased outside of established National Forest Units will, in all probability, be paid for out of state or local funds, and be administered as state or other local public forest.

The expected ownership pattern of woodland under the recommended program is shown in Table B-1.

FEDERAL LANDS

In addition to National Forest lands, there are several other tracts of land owned and administered by the Federal Government. The Blue Ridge Parkway, administered by Department of the Interior, extends across the upper end of the watershed. A land use project of 14,061 acres is located in Caswell County, North Carolina. This project is managed by the Soil Conservation Service under the Bankhead-Jones Farm Tenant Act. There are approximately 70,300 acres of Federal lands adjacent and in addition to 54,100 acres inundated by power pools in Buggs Island and Philpott Reservoirs. These lands are at present administered by the Department of the Army, Corps of Engineers.

LEGISLATIVE FACTORS

North Carolina and Virginia have enacted legislation under which soil conservation districts were organized and were actively operating throughout the entire drainage basin in 1948. These districts will facilitate the application of remedial measures if the recommended program is authorized.

Both states also have laws for the organization of drainage districts, but when the flood control survey was completed (1948), no operating drainage districts were located within the watershed boundary.

The Weeks Act of 1911 and the Clarke-McNary Act of 1924 provide for Federal acquisition for watershed protection or timber production provided the states consent to such acquisition. North Carolina and Virginia have passed enabling acts consenting to Federal acquisition. However, the Flood Control Act of 1944 requires specific state enabling legislation for acquisition of lands for flood control purposes. Such legislation has not been passed because no specific cases have previously arisen in these states which indicated need for such action.

The Fulmer Act of 1935 provided for state ownership of forest lands acquired with Federal funds. However, not an acre of land has been purchased under this Act.

Procedures are established in North Carolina for acquiring title to tax reverted lands by counties that may in turn transfer such lands as the Department of Conservation and Development deems useful in establishing state forests.

The Clarke-McNary Act of 1924 provides for Federal-State cooperation on a fund matching basis in fire control and forest planting. The Norris-Doxey Farm Forestry Act of 1937 provides for Federal contributions to the states for technical assistance to woodland owners in woodland management, including planting and silvicultural treatment, protection, and the harvesting, utilization, and marketing of forest products.

The states of North Carolina and Virginia are actively cooperating with the Federal Government in the activities authorized by the above mentioned laws. This forms an excellent basis for expediting the application of any authorized watershed treatment program.

Table B-1.--Roanoke River watershed--present and future ownership of woodland

	Private woodland		Total	Public woodland			Total	All Woodland
	Farm	Nonfarm		National forest	National park 1/	State and other 2/ public		
	acres	acres	acres	acres	acres	acres	acres	acres
Present	2,275,966	1,140,099	3,416,065	12,338	11,580	74,644	98,562	3,514,627
Future	2,457,286	1,070,099	3,527,385	22,338	11,580	134,644	168,562	3,695,947

1/ All noncommercial forest land

2/ Includes 13,234 acres in a U. S. Government land-use project and 45,000 acres in Buggs Island Reservoir. 16,410 acres are noncommercial forest land.

APPENDIX C

HYDROLOGY

ROANOKE RIVER WATERSHED

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TABLES

No.

FIGURES

PROCEDURE FOR CALCULATING FLOOD REDUCTIONS

Hydrologic investigations were conducted to determine flood reductions which might be expected as a result of the recommended program. To simplify the determination of present and future damages and benefits which would accrue from the program, the evaluation was undertaken on (a) tributaries and (b) reaches of the main streams of the Roanoke River system. Procedures followed in connection with this phase of the survey are discussed in that order.

Basic data, computations, analyses, and detailed information used in developing the hydrology appendix are filed in the Soil Conservation Service office at Washington, D. C., or in the Southeastern Regional office.

TRIBUTARIES

The Roanoke River drainage area was divided into Physical Land Units which, under similar cover and treatment, produce fairly uniform runoff, sediment production, and deterioration of soil resources. Sample tributaries were selected to represent these Physical Land Units. The location of the Physical Land Units and of the sample stream drainage areas selected to represent each is shown in Figure C-1.

Two sample tributaries were selected for the Piedmont Physical Land Unit because its area is so much greater than that of the other Physical Land Units, and because no single sample could be found which seemed representative of both the Dan River drainage area and the remaining part.

Quankey Creek is the sample tributary selected for the Coastal Plain Physical Land Unit. Since the survey party determined there were no agricultural damages nor possible benefits, no hydrologic computations were necessary.

Description of the Sample Tributaries

1. The headwaters of the Roanoke River above the river gaging station at Lafayette, Va., were selected as the sample for the Limestone Valley Physical Land Unit. The watershed above the gage is roughly rectangular in shape with the gage on one of the long sides. This area is 257 square miles. The drainage pattern is approximately fan-shaped since the North and South Forks of the Roanoke River have their confluence just above the gage. About 20 percent of the drainage area, situated on the headwaters of the South Fork, is within the Mountain-Foothills Physical Land Unit. This does not affect its value as a sample for the Limestone Valley Physical Land Unit since the part lying within the Mountain-Foothills is in a transition zone which had hydrologic features reasonably similar to those of the Limestone Valley Area. Nearly all the drainage area above Lafayette lies more than 1,200 feet above sea level, much of it being very rugged with steep slopes. The stream slope is approximately 20 feet per mile to the upper reaches.

2. Blackwater River above the gage near Union Hall, Va., was selected to represent the tributaries in the Mountain-Foothills Physical Land Unit. The drainage area contains 208 square miles and is roughly triangular in shape (25 miles long by about 16 miles on the base) with the gage near the apex of the triangle. The watershed lies from 700 feet to 2,500 feet above sea level with the greater part below 1,500 feet. From Union Hall to the junction of the North Fork and the South Fork, the slope is about 8 feet per mile; above this point the slope increases quickly, averaging over 100 feet per mile for the approximate 12 miles to headwaters.

About 30 percent of the area extends into the Piedmont Physical Land Unit. This portion lies in a transition zone, however, which does not differ greatly from the Mountain-Foothills Area in its hydrologic features. It was necessary to include this lower portion of the drainage area in the sample to permit the use, in connection with the hydrologic analysis, of the 22-year stream flow record of the gage near Union Hall.

3. Sandy River above the gage near Danville, Va., was selected to represent the tributaries in that part of the Piedmont Plateau Physical Land Unit lying within the Dan River drainage area. The watershed above the gage has an area of 113 square miles and is an irregular rectangle (14 miles by 8 miles) with the gage located at one corner. The stream flows through the middle of the area with the tributaries on each side about equal in number and size.

The drainage area lies from about 450 feet to 900 feet above sea level. It is of moderately rough topography over nearly the entire area. The stream, from the gage to the upper reaches, is about 25 miles long and has an approximate average slope of 15 feet per mile.

4. Falling River above the gage near Naruna, Va., was selected to represent the tributaries in all that part of the Piedmont Physical Land Unit lying outside the Dan River drainage area. The watershed area above the gage is 172 square miles. It is an irregular triangle about 20 miles long and 16 miles wide with the gage at one apex. Several large tributaries enter the stream at different points between the gage and 7 miles above, making the drainage pattern approximately fan-shaped. The whole area is well-drained.

The drainage area lies from about 400 feet to about 900 feet above sea level. It is of rolling and moderately rough topography over most of the area. The average stream slope is approximately 6 feet per mile from the gage to the point, 7 miles above, where Big Falling Creek flows into Falling River. The next 15 miles (to headwaters) has an average slope of about 14 feet per mile; beyond this the slope increases rapidly averaging about 90 feet per mile for the next two miles.

Availability of Precipitation and Stream-flow Data

Records of daily rainfall from standard U. S. Weather Bureau depth-of-precipitation gages were reasonably plentiful over the watershed. Some of these were of long duration. Thus Lynchburg, Va., had a 76-year record; Weldon, N. C., and Tarboro, N. C, (in the Coastal Plain) had 70 years or over. Stations which had 50 or more years of record are Blacksburg, Clarksville, Danville, Roanoke, Rocky Mount in Virginia, and Henderson, Mount Airy, Scotland Neck and Winston-Salem in North Carolina. Some of these are not located within the watershed, but their "Horton-Thiessen polygons" extend within. The Horton-Thiessen weights for each of the sample tributaries, for as long a period as required for the analysis, are shown in Table C-1. The periods of record of the rain gage stations used in the analysis, starting with the year 1921, are shown in Figure C-2.

Rainfall intensity-of-precipitation records were very scarce at points within or near the watershed, and those sufficiently detailed to be useful were of short duration. See "Development of Infiltration Data" below.

Stream-flow records were reasonably numerous both on the main streams and on the tributaries. In the Coastal Plain, however, none on tributary streams was available. Records on the selected sample tributaries were mostly long enough to be used in the analysis without requiring extension from data gathered on other streams.

Outline of the Procedure for Evaluating the Recommended Program

The major phases of the procedure used to evaluate the effect of the recommended program on each sample tributary and to expand these data to the Physical Land Units are briefly outlined below.

1. Rainfall versus runoff relations were developed for each sample tributary using actual stream-flow and precipitation records.

2. An evaluation series of floods was developed for each sample tributary.

3. Infiltration data used in this survey were derived by a simplified formula method. Local soil, cover, and hydrologic conditions were taken account of by the use of special coefficients in a general formula. The major steps used in the application of the formula are listed below.

   a. An analysis was made of the best available rainfall record from a recording gage (intensity of precipitation data) typical so far as possible of the whole watershed. This included computing various characteristics of a group of average storms from 1.50 inches to 6.00 inches total precipitation.

b. The soils in the watershed were classified as to texture and the area of each determined by Physical Land Units.

c. Cover conditions were classified in accordance with the classification set up by the coefficients in the formula. This in combination with the soil classification of (b) gives the evaluation classes used in this phase of the investigation.

d. The area of each evaluation class in each sample tributary was determined and listed. This was done for both present conditions and future conditions (after land treatment measures have been applied).

e. An index (θ) was computed for each evaluation class in each sample tributary using the infiltration formula and the average rainfall vs. runoff relation of 1 above. This index (θ) measured in inches per hour indicates the infiltration rate and was adjusted to conform with the measured P vs. Y relation.

f. Using these values of θ and the areas of each evaluation class (both present and future), computed storm runoffs (P_c) were determined for each evaluation class and for the whole sample tributary for each of the average storms. This gave P_c vs. P relations for the sample tributary for both present and future.

4. Studies were made of all floods in the evaluation series to determine the reduction in peak flow that would result in the Mountain-Foothills and Piedmont Plateau Physical Land Units from channel improvement.

5. Peak stages for future conditions (after channel improvement alone, and after both channel improvement and recommended land use measures are applied) were determined for each flood in the evaluation series. See "Effect of the Recommended Program on Flood Reductions."

6. The areas inundated by each flood: (1) under present conditions, (2) after channel improvement, and (3) after channel improvement and land treatment measures combined, were determined from the peak stages of 5 above. With this information, it was possible to estimate the flood damages over the period covered by the evaluation series of floods.

Each of the above-listed steps is explained more fully in the following sections.

PRESENT STORM DISCHARGES

Rainfall versus Runoff Relations

Rainfall versus runoff relations were developed for each sample tributary using available stream-flow and precipitation data. Depth of rainfall (P) over the watershed was computed using the Horton-Thiessen method of distributing recorded precipitation. See Table C-1 for the weights used for each sample tributary. Total discharge (volume) was computed using the discharge hydrographs for the storm periods plotted from stream-flow data. Ground-water inflow into the stream was determined by a simplified method based on the ground-water depletion curve. Total discharge (volume) during the flood period less ground-water flow gave the "storm discharge," (Y). These computations were made for each storm occurring in the evaluation series. The results were plotted and an average P vs. Y curve was derived for each sample tributary. Seasonal curves were not used, one curve only being drawn for each sample. Past experience with a seasonal break-down in adjacent watersheds has not been satisfactory. Seasonal differences in the P vs. Y relation do appear, but they are neither large enough nor consistent enough to be useful.

Average Peak Stage versus Discharge curves were developed for use in determining the stage versus area of inundation relation. Peak stage for each significant storm was plotted against the storm discharge, (Y), and an average curve drawn. The P vs. Y and peak stage vs. Y curves for Blackwater River are shown in Figures C-3 and C-4.

The Evaluation Series of Floods

1. Roanoke River headwaters above the gage at Lafayette, Va.: Stream-flow records were available for only 3 years (Oct. 1, 1943 to September 30, 1946). The 13 definite rises which occurred during this period were used as a preliminary evaluation series of floods and an approximate P vs. Y relation established. A similar analysis was made for 15 definite rises occurring at Roanoke, Va., during the same 3-year period in order to tie in the Lafayette gage with the 47-year Roanoke gage record. The approximate P vs. Y curves for the two stations, based on the same 3-year period, were practically identical (Y = 1.65 inches for P = 4.00 inches, with an approximate straight-line relation). Also, the storms common to the two series of rises gave an approximate relationship between readings on the gages at Lafayette and Roanoke. Using these results, the Lafayette record was extended. However, due to the small flood damages occurring in this sample and the limited benefits probably accruing from the land use measures, damages and benefits for this sample tributary were based directly on damage schedules obtained in the field.

2. Blackwater River: The actual series of floods recorded at the gage on Blackwater River for 22 years (Jan. 1, 1925 to Dec. 31, 1946)

was used as the evaluation series of flood events. During this 22-year period, 71 definite rises occurred; these were analyzed for the P vs. Y relation. However, not all of these produced out-of-bank flow. Bankfull stage is about 5.8 on the Blackwater. Table C-2 (two sheets) lists the 56 rises which were above approximate bankfull stage and hence caused flood damage.

3. Sandy River: The actual series of floods recorded at the gage on Sandy River for 17 years (Nov. 1929 to Oct. 31, 1946) was used as the evaluation series of flood events. During this 17-year period, 44 definite rises occurred; these were analyzed for the P vs. Y relation. However, not all of these went high enough above bankfull stage to cause appreciable flood damage. Rises having a peak gage reading (at the present gage location) of less than 5.8 feet caused only insignificant damage.

4. Falling River: The series of floods for a 14-year period of record (1928-1934, 1940-1946, all inclusive) was used as the evaluation series of flood events. Records available at the gage near Naruna, Va., were from July 1929 to January 1935 and from September 1941 to September 1946. This record was extended to the end of the 1946 calendar year by information from the U. S. Geological Survey and by examination of rainfall records; no rain of flood-producing size occurred at any nearby rain-gages. The record was extended backwards to January 1928 (from July 1929) by comparison with the records on the Roanoke River at Brookneal, Va., and the adjacent rainfall records. One very important flood (of August 11-13, 1928) occurred during this period, but the peak stage attained by the flood waters of this storm was known from flood marks, giving a check on the result obtained by comparison. The other rises during this period were either below bankfull stage or only a foot or two above. Finally, the record was extended from January 1940 to August 1941 by use of the record at a nearby station on the same stream (Falling River near Brookneal, Va., discontinued after September 1941) supplemented by comparison with the record on the Roanoke River at Brookneal, Va., and adjacent rainfall records. The important August 1940 flood occurred during this period, but its peak stage was known from flood marks at a number of nearby localities. In all, 49 rises were studied, 36 of these being analyzed in detail from the record of the gage near Naruna, Va. Many of these were below the approximate 14-foot bankfull stage.

Development of Infiltration Data

The Infiltration Formula - Infiltration data from the entire United States have been collected and analyzed by the Washington office. The result has been condensed into an empirical infiltration formula (in two parts) which simplified very greatly the application of the data to actual cases. The formula is:

$$\theta = C\,[.178 + (S + k)] - .178, \qquad \text{when } S + k > .20,$$

$$\theta = C\,[.604 + (S + k)] - .604 \qquad \text{when } S + k < .20$$

The symbols in the formula are explained in the following paragraphs.

The coefficient S was introduced into the formula to measure the effect of soil on the infiltration rate by using the soil texture. See "Soil Classification."

The coefficient C, introduced into the formula to measure the effect of cover conditions on the runoff, is described with a listing of values under the heading: "Cover Conditions; Evaluation Classes."

The watershed coefficient (correction factor) k and the index θ are explained under the heading: "Computation of the Index θ."

The factor k was determined by a trial and error process. Its purpose is to adjust the computed runoff so that it equals average measured runoff for present watershed conditions. The values of θ, for each evaluation class, were computed using the value of k and corresponding values of C and S. These computations were made for present conditions, and it was then assumed that the watershed factor k would remain the same in the future, after the land treatment measures have been applied.

Detailed instructions and explanations are not given here for the use of the formula since these are available in Regional and Washington files of the Soil Conservation Service. However, in the sections immediately following, all methodology especially applicable to this survey is given with the computations required before the formula itself can be applied.

Analysis of Intensity of Precipitation Records - As mentioned under "Availability of Precipitation and Stream-Flow Data," daily rainfall records were adequate in the Roanoke River Watershed, but intensity of precipitation records were scanty. On this account it was decided to use the records from the Statesville, N. C. station as more likely to be representative of the Piedmont and Mountain-Foothills Physical Land Units than were available records nearer to the Roanoke River Watershed. Roanoke, Va., and Lynchburg, Va., are first-order weather bureau stations. Roanoke is in the Limestone Valley Physical Land Unit, however, and Lynchburg is in the transition stage between the upper Piedmont Plateau Physical Land Unit and the Mountain-Foothills Unit. Lynchburg is fairly typical of the Mountain-Foothills but not of the much more important Piedmont Plateau, while Roanoke is typical of neither. The infiltration formula was applied to one tributary in the Mountain-Foothills and to two in the Piedmont Plateau; hence a station like Statesville having mainly Piedmont characteristics was needed.

An analysis of the Statesville records was made by standard methods and is available. Only the items needed in the application of the infiltration formula are given below:

I = Rainfall intensity at a given instant or during a definite time interval in inches per hour.

I_{max} = Maximum intensity occurring during the storm under investigation. The accuracy with which this is known depends some-

what on the type of automatic rain gage used--the older "tipping bucket" gage does not give very accurately intensities which lasted for very short intervals.

P = Total precipitation during the storm period, in inches.

P_c = Precipitation "over and above" a given intensity. This "given rate" (I) may be any rate whatever (even zero) in the theoretical analysis and the diagrams used with it. In application, the "given rate" is often the average rate of infiltration for the area being analyzed; in that case, the value P_c will be approximately equal to the volume of the storm runoff.

Two relationships in particular were needed.

First, an average relation between P and I_{max} was needed, where P and I_{max} are those for the same storm. This relation varies widely between different storms, but the Statesville data indicate as a reasonable average the values:

I_{max} = 2.0 inches per hour for P = 1.50 inches or less,

I_{max} = 2.5 inches per hour for P = 3.50 inches,

I_{max} = 3.0 inches per hour for P = 6.00 inches.

Values of I_{max} for intermediate P values, if needed, may be found by direct interpolation.

Second, the so-called "dimensionless diagram" showing the average relation between I/I_{max} and P_c/P for all storms occurring during the period of record was needed. This is shown, for the Statesville data, in Figure C-5

From these two relationships it was possible to compute average "P_c curves" for design storms. The curves used in this survey are shown in Figure C-6.

A "P_c curve" or "Rainfall Excess Graph" is a curve showing, for an actual storm or a design storm, the values of P_c corresponding to various values of the storm intensity. The curves were computed as P_c curves using I for the vertical axis. The "given rate" of the definition of P_c is taken as the average rate of infiltration (θ) for the area under examination; then the corresponding value of P_c is approximately equal to the volume of storm runoff from this area. Thus for this particular area, the value P_c for corresponding values of θ or I equals the storm runoff.

Soil Classification - A classification of the soils in the watershed was made with respect to texture. Texture in this case is defined as the relative proportion of the three size groups (clay, silt, and sand) of individual grains in the soil; these were found originally by mechanical analysis or by field determination. This classification was made solely for use in the infiltration formula and thus occasionall

grouped together soils which are not similar in other respects. Since the infiltration formula method was not used in the Limestone Valley Physical Land Unit nor in the Coastal Plain, the texture classification was not made for these Units. See Table C-3 for the details including areas within the sample tributaries and the percentages which define the texture.

A value of the coefficient S of the infiltration formula corresponds to each set of the three percentages which define the texture of a given soil. This value S is found by using a triangular chart, not reproduced in this Appendix, but available in the files.

Cover Conditions, Evaluation Classes - A cover condition classification for hydrologic use is required for the infiltration formula. This formula contains a cover coefficient ("factor of cover") C, which has various values according to the kind of cover. The cover classification need not be a very detailed one for our present purposes, hence it groups together some of the individual classes contained in the classification used in planning the land treatment measures.

The values of the "cover coefficient" C as used in the infiltration formula, for the cover conditions occurring in the watershed, are as follows:

VALUES OF COVER COEFFICIENT C

Cover Description	C	
	$S+k < .20$	$S+k > .20$
Row Crops* and Miscellaneous	1.00	1.00
Poor Pasture and Poor Abandoned	1.02	1.042
Woodland Hydrologic Condition Class III	1.04	1.094
Small Grain and Good Abandoned	1.09	1.185
Mea. Past., Close Growing, and Poor Kudzu	1.17	1.360
Good Pasture and Woodland Hydrologic Condition Class II	1.25	1.541
Good Kudzu and Woodland Hydrologic Condition Class I	1.36	1.770

*Row crops are in this first (poorest) class for present conditions. For future conditions, row crops are classed with Poor Pasture, etc., as the improved practices recommended in the land treatment measures should also increase the infiltration rates for land in row crops.

Each of the seven cover types just listed, for each soil classification, gives an evaluation class corresponding to the "soil-cover complex" used in the analysis of infiltration data.

Areas of Evaluation Classes in each Sample Tributary - The area of each evaluation class was determined in each of the Physical Land

Units for which the infiltration formula was used. The areas were taken from the tables used in planning land treatment measures and regrouped according to the hydrologic "evaluation classes."

The stream discharges (which are known for the period of record) are the discharges coming from the present distribution of cover conditions assuming that no radical changes in cropping practices, etc., have taken place during this period of record. Hence, in order to make measured flood discharges and present evaluation class areas comparable, these areas for the sample tributaries were taken as the actual present areas within the sample. Sufficient field investigations were made to verify that no extensive changes in land use practices have occurred within the period of record.

For future conditions, the determination of the areas recommended for the land use measures was made on a Physical Land Unit basis. Hence these computed areas were used for the future conditions and scaled down by proportion to give the corresponding sample tributary future evaluation areas. If a sample tributary represented its Physical Land Unit exactly in all respects, the present and future areas in the sample tributaries, found by this procedure, would be exactly comparable. In practice there may be some lack of agreement, but it is believed to be very small as the sample tributaries seem reasonably representative.

Computation of the Index θ - A value of C and of S was determined for each evaluation class, as previously explained. In order to compute θ for an evaluation class, we must also know the "watershed correction factor" k. The values of θ and k are in practice computed simultaneously by a trial and error method. The factor k must have such a value that the total computed storm runoff (P_0 or Y) from the watershed, found by using this k and the corresponding θ values, will equal the average observed storm runoff found from the analysis of the records. An arbitrary value of k (say $k = 0$) was assumed, and the θ values for each evaluation class computed using the formula with this k. From these θ values the computed storm runoff was determined for the design storm. This computed runoff was then compared with the observed average runoff, and if it did not check, a new value of k was assumed and the process repeated until the computed and observed average runoffs were closely equal for the design storm.

As an example, consider the evaluation class: Woodland Hydrologic Condition Class III, Cecil Fine Sandy Loam, for which $C = 1.094$ and $S = 0.575$. Thus, for $k = 0$, we have $S + k = 0.575$. These values, substituted in the infiltration formula, give $\theta = 0.646$ inches per hour. We will use the design storm No. 4 ($P = 3.50$ inches) of Figure C-6. Entering curve No. 4 in Figure C-6 with $\theta = 0.646$, we get $P_0 = 0.76$ inches. The area of the chosen evaluation class in the present Blackwater River Watershed is 41.8 square miles. Thus the volume of the computed storm runoff from the land in this evaluation class is $Y = 41.8 \times 0.76 = 31.77$ mile-inches.

A similar computation was made for each evaluation class using its area under present conditions. The total computed storm runoff Y for P = 3.50 inches, with assumed k = 0, on the Blackwater River Watershed was found to be 166.65 mile-inches. This, when divided by the watershed area (208 square miles), gave a computed storm runoff of 0.80 inches. The curve of Figure C-3 shows however that the average Y for P = 3.50 inches is about 1.12 inches. Thus a new value must be assumed for k and the computation repeated. Three or four trials will usually determine a value of k giving a computed storm runoff of 1.12 inches from a rain of 3.50 inches.

The value of k = -0.147 was found to give the required present runoff of 1.12 inches for P = 3.5 inches. This value of k was then used to compute the runoff for P = 1.5 inches and P = 6.0 inches, giving 0.38 inches and 2.26 inches, respectively. These agreed very closely with the values found from the previously drawn P versus Y curve. Hence k = -0.147 was taken as the watershed correction factor.

Computation of Storm Runoff, Present and Future - It was assumed that in the future approximately the same general hydrologic and climatic conditions will hold as at present, the only difference being the areas of each evaluation class. The watershed correction factor k, computed as described above, was used for both present and future conditions and for all design storms.

The results of this computation for the Blackwater River sample tributary are shown in Figure C-7. The computed values for present conditions of course agree with those shown in Figure C-3, since the watershed correction factor k was selected to satisfy this condition.

The use of the infiltration formula automatically makes the computed P versus P_e (or Y) relation for present conditions the same as the present average P versus Y relation obtained from the analysis of the rainfall-runoff data. This would also be true if the formula were applied directly to a watershed having an appreciable amount of quick return flow ("subsurface runoff").

Surface runoff is determined from infiltration data when subsurface runoff is not present, but if such subsurface runoff occurs, it must be evaluated independently before surface runoff can be known. There are areas of thin profile soils in the watershed and some subsurface flow is undoubtedly present in the storm runoff. However, in determining future runoff, the proportion of subsurface flow does not appear large enough to require modification of the direct application of the infiltration theory.

Results from the P versus Y investigation for the sample tributaries confirm the above conclusion. The table following gives average observed Y values for a four-inch rain for various tributary watersheds. Since the P versus Y average curves are approximately similar in shape for streams in this locality, the average Y value for a single heavy rainfall is sufficient to give comparative results.

STORM RUNOFF (Y) VALUES FOR P = 4.00 INCHES

Tributary	Physical Land Unit	Y (inches) for P = 4.00 in.
Roanoke River		
Upper Roanoke River	Limestone Valley	1.65
Blackwater River	Mountain-Foothills	1.33
Falling River	Piedmont Plateau	1.25
Sandy River	Piedmont Plateau	1.60
Pee Dee River		
Fisher River	Mountain-Foothills	2.15
Third Creek	Piedmont Plateau	1.25
Savannah River		
Keowee River	Mountain-Foothills	1.33
Broad River	Piedmont Plateau	1.27
Little River (S. C.)	Piedmont Plateau	1.72

Fisher River, with Y = 2.15 inches when P = 4.00 inches is known to have considerable quick return flow. The other figure listed for the Pee Dee River and the Savannah River Watersheds are known to include no appreciable amounts of such return flow. The range of values of Y for the Roanoke River tributaries falls within the range of the average tributary for streams of similar topography and climate, considerably below the Fisher River value. This confirms the result indicated by the gelogical investigation.

Future Storm Runoff from Wooded Areas - As described in Appendix A, the amount of forest area in each of the hydrologic condition classes after 15 years is determined from the present cover conditions. Existing data indicate that good forest management improves watershed conditions well beyond such a period. But it was decided to claim as benefits only the improvement in forest-floor conditions that are anticipated after the first 15 years of good forest management.

To predict the future hydrologic condition of the present stands, the growth expected under the recommended program was projected for 15 years. Then existing stands were found that were comparable to these theoretical stands and the future distribution of hydrologic conditions was determined from them. The changes in woodland hydrologic condition classes for the "fine sandy loams (upland soils)" soil group in terms of the Index θ were as follows:

Present woodland hydrologic condition class		Future woodland hydrologic condition class
III - θ = 0.485 in./hr.	to	II - θ = 0.702 in./hr.
II - θ = 0.756 in./hr.	to	I - θ = 0.867 in./hr.
I - θ = 0.895 in./hr.	-	I - θ = 0.895 in./hr.

Similar changes were made for the other soil groups.

Channel Improvement

Reconnaissance showed that simple channel improvement work such as snagging, and tree removal from the channel itself, would in general be beneficial in the Mountain-Foothills and Piedmont Physical Land Units. An investigation was therefore made, for the three sample tributaries representing these Physical Land Units, to determine the effect of such measures from the hydrologic standpoint.

Standard methods were used in this investigation. Approximate gage height versus discharge curves (rating curves) for present conditions and for the future conditions after channel improvement, were determined at one or more typical cross-sections of the stream. The reduction in gage height, for a given discharge, due to channel improvement can then be found from these curves.

Previous field work gave the values of the water-surface slope "S" at the selected cross-sections, the cross-section itself, and careful notes about conditions affecting the present value of "n", the so-called "coefficient of roughness" in Manning's formula. "Slope-Area" computations by Manning's formula, using this present value of n, gave the present rating curve. As a check on the estimated values of present n, a preliminary computation was made in each case for the cross-section at the stream gage. Here an accurate rating curve was available from U. S. Geological Survey records; and with this rating curve and the measured water-surface slope the values of n can be determined which, substituted in Manning's formula, will reproduce the rating curve. The values of n computed in this way agreed reasonably well with those given in the field notes. When the cross-section at the stream gage seemed to be representative of the general valley conditions in the stream, this cross-section was given major weight in the investigation because of its known present rating curve. When the gage cross-section was not representative (usually because it had too narrow a floodplain to represent average valley conditions) one or more other cross-sections were investigated, and the results used in determining the final rating curves for present and future.

For conditions after channel improvement, the same slope S and the same cross-sectional values were used as for present conditions. New values of n were used for the future channel section, however. This value of n was based on our best estimate of future conditions. Actual discharge measurements, with computations for n before and after channel improvement, have been made by various agencies on streams comparable to those in the Roanoke River Watershed; those results were considered in selecting future values of n. The value of n for the overflow section (floodplain) was kept the same for the future as for the present since no improvement in the floodplain is contemplated by the channel improvement measure.

Present and future rating curves for the Blackwater River sample tributary (representing the Mountain-Foothills Physical Land Unit) are shown in Figure C-8. On this stream the gage cross-section was sufficiently typical of the general valley conditions so that it could be used directly. Present values of n for the channel section averaged about 0.043; future values were taken at about 0.035 average.

For the Falling River sample tributary, representative of all the Piedmont Plateau Physical Land Unit except the Dan River Watershed, the present and estimated future values of n were slightly lower than for the Blackwater, averaging about 0.041 for present and 0.034 after channel improvement. On the Sandy River sample tributary, representing the Dan River portion of the Piedmont Plateau, there was more growth on the channel banks and in the channel itself reflected by the higher present value n = 0.048 (average). Future n was estimated as averaging n = 0.039.

Future peak stages, to result from channel improvement, were found for each storm in the evaluation series as follows: Consider as an example the storm of August 11, 1928 (see Table C-2). The peak stage, corresponding to its precipitation, was 18.2 feet. Entering the present rating curve of Figure C-8, we see that a gage reading of 18.2 feet gives a discharge of 16,000 cubic feet per second. After channel improvement, the discharge for this storm would still be 16,000 c.f.s. but, due to a smoother channel, this discharge could be carried with a lower gage reading. To find this new gage reading, enter the future rating curve of Figure C-8 for 16,000 c.f.s. and it is seen that it corresponds to a gage reading of 17.1. Thus, for this storm there is a peak reduction, due to channel improvement, of $100 \times (18.2 - 17.1)/18.2 = 6.0$ percent.

These results are also plotted in Figure C-4 where present and future peak stages are plotted against the volume of storm runoff V_s for average conditions.

Effect of the Recommended Program on Flood Reductions

The present and future P_o versus P relations, previously found for each sample tributary, were used to determine the hydrologic effect of the recommended land use measures. These P_o versus P relations were assumed to apply in general to the Physical Land Unit represented by the sample. Thus, Figure C-7 gives the curves used for both the Blackwater River Sample tributary and for the Mountain-Foothills Physical Land Unit.

Various values found by the use of the Blackwater River curves of Figure C-7 are listed in Table C-2. As an example, consider the storm of September 6, 1928. Present storm runoff (Y or P_o) is 1.12 inches. Entering the "present" curve of Figure C-7 at Y = 1.12 and dropping down vertically to the "future" curve, the value Y = 0.80 inches was found as the future runoff from a storm with the same precipitation. This is future Y for conditions after the recommended program is in effect. The "present" curve of Figure C-4 gives peak stages corresponding to any value of Y (present and future) assuming no channel improvement has been made. Thus for Y = 1.12 inches this curve gives 11.9 foot peak stage; this is the present average peak stage for a storm having the precipitation (P = 3.49 in.) of this storm. The lower curve of Figure C-4 ("gage heights after channel improvement") gives 9.4 feet gage height for Y = 0.80 inches. This is listed in Table C-2 as future stage; it is the peak stage expected to occur from this storm after land use measures and channel improvement have both been applied.

Table C-2 lists corresponding values for all storms in the evaluating series used for the Mountain-Foothills Physical Land Unit. Similar tables for the two parts of the Piedmont Plateau are in the files. The corresponding table for the Limestone Valley (represented by the Upper Roanoke River as sample tributary) was not computed.

Stage vs. Area Inundated

Area inundated for various stages of storm discharge was determined for the three sample tributaries representing the Mountain-Foothills and Piedmont Physical Land Units in the following manner:

1. A profile of mean low water elevation, referenced to the gage on the stream, was obtained by field survey. Representative channel and valley cross-sections were obtained at the same time; these were located at approximately uniform intervals insofar as this could be done without excessive field work. This profile and the series of cross-sections extended from the gage location to a point above which the drainage area was approximately three square miles; in general, inundation was not significant above this point. The profile and cross-sections were plotted to scale.

2. High water marks of historic floods at various points were determined by field investigation and referenced to the profile. Field work was concentrated on two selected floods of fairly recent date having flood crests different enough to give two maximum crest lines reasonably far apart on the floodplain.

3. The high water marks were plotted on the aerial photographs and their elevations indicated. Profile elevations were located on the photographs, and the cross-sections were plotted to scale, with elevations shown. Any other points whose position and elevation were known were also plotted on the photographs.

4. With the aid of these points located on the aerial photographs, the line of maximum inundation (boundary of the area of inundation) was drawn on the photographs by stereoscopic methods for each of the two selected floods. This line of maximum inundation, or maximum crest line, of a flood is not a contour line, but in general it is sufficiently near level so that a stereoscope can be used.

5. The area inundated by each of the two selected floods was then planimetered directly from the aerial photographs. Reaches of the streams were used, for convenience, based on the surveyed cross-sections and on intermediate cross-section lines located approximately on the photographs.

6. Areas inundated by floods of gage heights intermediate between the two selected floods, and by floods greater or less than those two, were found by reaches by an approximate formula. This formula assumes that for a given stage the ratio of the area inundated at that stage, to the planimetered maximum area inundated for a given reach, is proportional to the ratio of the sum of the widths of inundation for the given stage to the sum of the widths of inundation for the maximum flood, the limiting sections of the reach being used for those widths. For assumed gage heights below or nearer the lower of the two selected floods, data from this lower flood was used instead of from the maximum flood. Since this area of inundation formula is approximate, results from it were examined for reasonableness and checks made if necessary, even to the extent of considering "concordant flows" at a cross-section when simpler methods did not decide the question.

The resulting gage heights versus area inundated relation for Blackwater River sample tributary is shown in Figure C-9. This relation was used, in the form of a table and reduced to area inundated per mile of stream, in computing damage and benefit figures. Similar data for the Piedmont sample streams are in the files.

Stage versus Duration of Inundation

Since in many cases the damage caused by flood inundation is clearly dependent upon the duration of time the fields are under water, it was necessary to consider duration of inundation. A study of the duration of inundation computed for each storm on the tributaries of the Coosa River above Rome, Georgia, showed that there was no significant relationship, from the standpoint of damage, between flood heights (only) and duration of inundation. Different floods of course result in different durations of inundation, but gage height or depth of flooding alone does not determine the average duration. Hence, the survey party handled this phase of the damage problem by methods not depending on a hydrologic investigation.

For many storms the duration of inundation for the various depths of inundation was about one-quarter day for depths of 1 and 2 feet, and one-half day for depths of 3 and 4 feet.

MAIN STREAMS

Preliminary plans for the main stream investigation called for the use of evaluation points at the Roanoke River gages at Roanoke Rapids, North Carolina, Clarksville, Virginia, Clover, Virginia, Brookneal, Virginia, and Toshes, Virginia, and at the Dan River gages at South Boston, Virginia, Danville, Virginia, Leaksville, North Carolina, and Francisco, North Carolina. Damage reaches to be used in the study of main stream damages and damage reductions were the reaches determined by these evaluation points. The gage records at these locations were adequate for a reasonably accurate determination of the hydrologic features of the past floods occurring within the period of record of each gage. However, estimates of future main stream floods and flood reductions would be only approximate.

Investigation by the members of the survey party on the probable damage reductions to be expected on the main streams, due to the measures recommended in the report, indicated that the detailed methods used in previous surveys were not required or advisable here. Probable total damage reductions on the main streams are not great enough to warrant such detail in this survey.

Enough data have been accumulated from previous surveys to give an approximate relation between tributary damage reductions and main stream damage reductions. As explained in Appendix D, damage figures from the Corps of Engineers, U. S. Army, have been adjusted to 1946 price levels. Benefits were obtained by using the relation just mentioned between tributary and main stream damage reductions by Physical Land Units. It is believed that the reductions thus obtained are as accurate as the available data warrant.

Main stream benefits were not claimed for the reaches below Buggs Island Reservoir on the Roanoke River and Philpott Reservoir on the Smith River, nor for the corresponding reservoir areas since such benefits appertain to the reservoir projects themselves.

See Appendix D - Damages, Benefits, and Costs - for details.

Table C-1

HORTON-THIESSEN WEIGHTS FOR THE SAMPLE TRIBUTARIES
ROANOKE RIVER WATERSHED

(Percent of Watershed Area in the Precipitation Polygon)

Sample Tributary	Period of Precipitation Record (All inclusive)	Precipitation Stations (Virginia): Blacksburg	Catawba Sanatorium	Floyd	Radford	Roanoke	Rocky Mount	Chatham	Danville	Martinsville	Appomattox	Lynchburg	Randolph
Upper Roanoke River	1921 - 1932	78	7	--	5	6	4	--	--	--	--	--	--
	1933 - 1946	70	7	11	5	5	2	--	--	--	--	--	--
Blackwater River	1921 - 1946	--	--	--	--	10	90	--	--	--	--	--	--
Sandy River	Jan. '21 - June '22 Dec. '22 - Apr. '23	--	--	--	--	--	--	--	100	--	--	--	--
	July '22 - Nov. '22 May '23 - Sept. '30	--	--	--	--	--	--	50	50	--	--	--	--
	Oct. 1930 - 1946	--	--	--	--	--	--	29	34	37	--	--	--
Falling River	1921 - Oct. 1937	--	--	--	--	--	--	--	--	--	--	96	4
	Nov. 1937 - 1946	--	--	--	--	--	--	--	--	--	75	25	--

Table C-2 (Sheet 1 of 2)
EVALUATION SERIES OF FLOODS 1/
BLACKWATER RIVER
(22-year Record)
ROANOKE RIVER WATERSHED

Storm Data		Present		Future			
					After Channel Improvement and after Land Program		
Date	Rain-fall P (in.)	Avg. Runoff Y (in.)	Avg. Peak Stage (ft.)	Peak Stage After Channel Impr. (ft.)	Average Y (in.)	Avg. Peak Stage (ft.)	Percent Reduction in Stage
12/26/26	1.88	0.50	7.5	7.1	0.35	5.5	26.7
2/20/27	3.85	1.27	12.7	11.7	.92	10.0	21.3
7/19/27	4.00	1.34	12.95	11.95	.965	10.2	21.2
8/20/27	2.16	.60	8.5	8.0	.42	6.25	26.5
7/13/28	2.39	.68	9.2	8.6	.48	6.9	25.0
8/11/28	7.43	3.30	18.2	17.1	2.50	15.25	16.2
8/16/28	3.16	.98	11.2	10.35	.705	8.8	21.4
9/6/28	3.49	1.12	11.9	11.0	.80	9.4	21.0
9/20/28	2.89	.875	10.6	9.8	.625	8.2	22.6
6/9/29	1.83	.49	7.4	7.0	.335	5.3	28.4
6/15/29	2.74	.81	10.1	9.45	.58	7.8	22.8
10/2/29	5.79	2.15	15.6	14.4	1.59	12.8	18.0
10/22/29	2.76	.82	10.2	9.5	.585	7.85	23.0
11/18/29	1.85	.50	7.4	7.1	.34	5.4	27.0
3/8/30	3.82	1.255	12.6	11.6	.905	9.9	21.4
8/22/31	3.20	1.00	11.3	10.45	.72	8.9	21.2
3/6/32	2.62	.765	9.8	9.1	.545	7.5	23.5
10/17/32	8.15	3.92	19.2	18.7	3.06	16.55	13.8
11/1/32	2.60	.76	9.8	9.1	.54	7.45	24.0
12/28/32	2.03	.55	8.0	7.55	.39	5.9	26.3
9/16/34	3.04	.94	10.95	10.1	.67	8.55	21.9
12/1/34	4.13	1.395	13.2	12.15	1.005	10.45	20.8
1/23/35	2.16	.60	8.5	8.0	.42	6.25	26.5
9/6/35	3.65	1.19	12.3	11.3	.85	9.7	21.1
1/3/36	2.04	.55	8.0	7.55	.39	5.9	26.3
1/19/36	2.08	.565	8.2	7.7	.40	6.0	26.8
2/14/36	1.90	.50	7.55	7.2	.35	5.5	27.2
3/18/36	2.74	.81	10.1	9.45	.58	7.8	22.8
10/17/36	4.28	1.455	13.4	12.35	1.05	10.65	20.5
1/3/37	2.05	.55	8.0	7.6	.39	5.9	26.2

Table C-2 (Sheet 2 of 2)
EVALUATION SERIES OF FLOODS 1/
BLACKWATER RIVER
(22-year Record)
ROANOKE RIVER WATERSHED

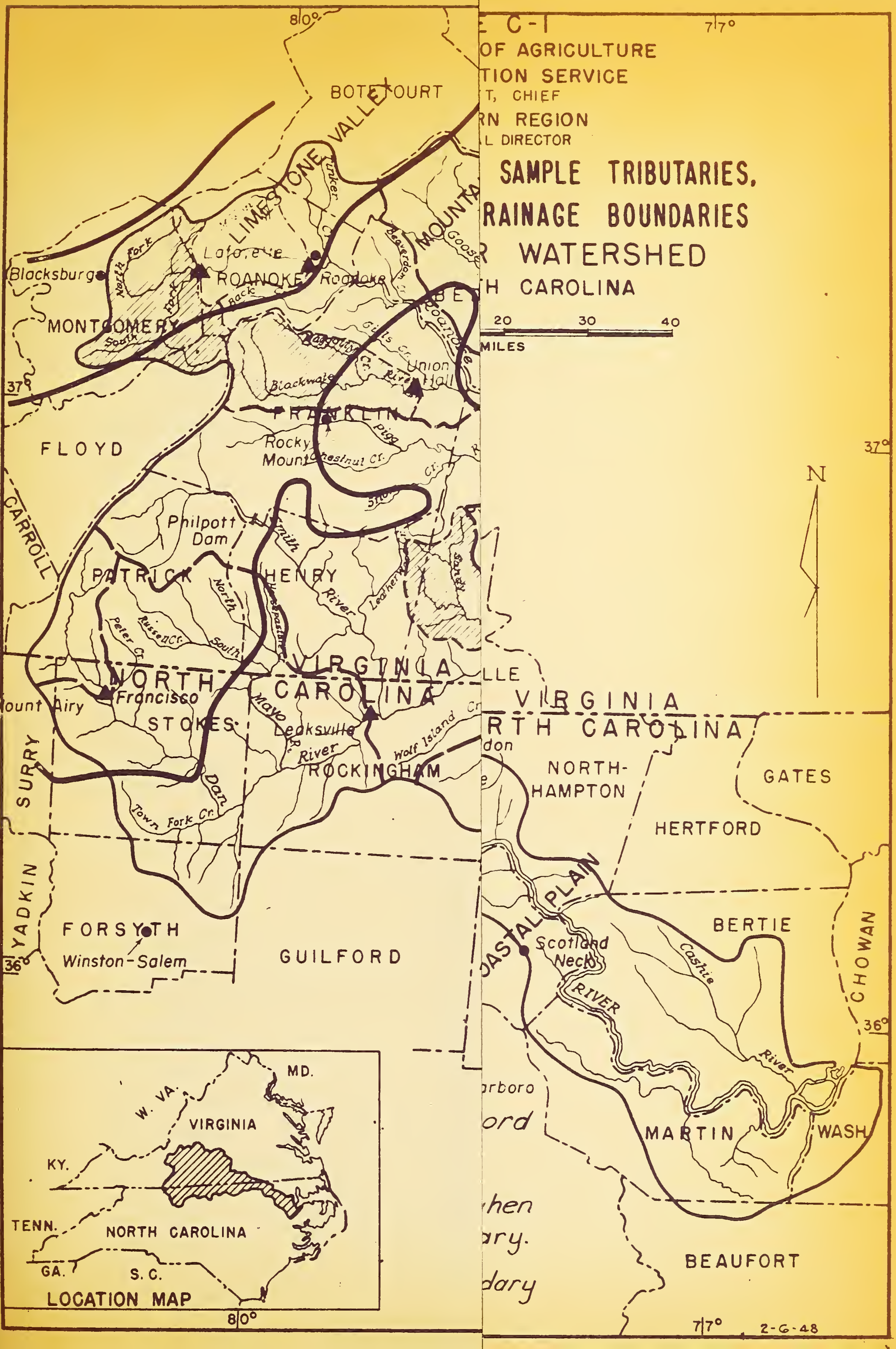
Storm Data		Present		Future			
					After Channel Improvement and after Land Program		
Date	Rain-fall P (in.)	Avg. Runoff Y (in.)	Avg. Peak Stage (ft.)	Peak Stage After Channel Impr. (ft.)	Average Y (in.)	Avg. Peak Stage (ft.)	Percent Reduction in Stage
1/20/37	2.12	0.58	8.3	7.8	0.405	6.1	26.5
4/26/37	2.99	.92	10.85	10.0	.655	8.45	22.1
8/25/37	3.01	.925	10.9	10.05	.66	8.5	22.0
8/31/37	1.77	.465	7.1	6.7	.315	5.05	28.9
10/4/37	2.96	.905	10.65	9.95	.645	8.3	22.1
10/20/37	4.48	1.55	13.8	12.7	1.105	10.95	20.7
6/22/38	2.04	.55	8.0	7.55	.39	5.9	26.2
7/20/38	4.21	1.43	13.3	12.25	1.03	10.6	20.3
2/11/39	2.11	.575	8.25	7.75	.40	6.05	26.7
7/29/39	3.11	.965	11.05	10.2	.695	8.65	21.7
8/19/30	2.88	.875	10.55	9.75	.625	8.2	22.3
4/20/40	2.06	.56	8.1	7.65	.395	5.95	26.5
5/25/40	2.47	.71	9.4	8.8	.50	7.1	24.5
5/30/40	3.74	1.22	12.45	11.45	.88	9.8	21.3
8/15/40	7.74	3.56	18.6	17.75	2.74	15.75	15.3
4/5/41	2.11	.575	8.25	7.75	.40	6.05	26.7
5/22/42	2.02	.545	7.95	7.5	.38	5.85	26.4
6/11/42	3.73	1.22	12.4	11.4	.88	9.8	21.0
12/30/42	1.75	.46	7.1	6.7	.31	5.0	29.6
4/19/42	2.91	.88	10.6	9.8	.63	8.25	22.2
7/10/43	3.43	1.095	11.8	10.9	.79	9.35	20.8
9/19/44	4.72	1.65	14.15	13.0	1.20	11.35	19.8
10/20/44	4.36	1.50	13.6	12.5	1.08	10.8	20.6
9/18/45	6.22	2.40	16.3	15.0	1.75	13.3	18.4
1/8/46	1.67	.43	6.7	6.3	.30	4.8	28.4
2/11/46	1.50	.38	6.2	5.85	.25	4.2	32.3

1/ The events listed here are limited to storms having a precipitation which, for the average storm, will produce out-of-bank flow. In studying rainfall-runoff relations 71 storms were analyzed; the 15 not listed above had a precipitation which, under average conditions, produced a peak stage of less than 6 feet on the gage.

Table C-3

SOIL CLASSIFICATION AS TO TEXTURE
ROANOKE RIVER WATERSHED
(For use in the Infiltration Formula)

Physical Land Unit and Soil Groups	Area in Sample Tributary (sq. miles)	Percentage Composition:		
		Clay	Silt	Sand
Mountain-Foothills				
Fine sandy loams (bottomland soils)	19.0	11	18	71
Fine sandy loams (upland soils)	96.9	15	20	65
Clays	23.0	34	27	39
Sandy loams	69.1	19	23	58
Piedmont (Dan River Watershed only)				
Fine sandy loams (bottomland soils)	10.7	11	18	71
Fine sandy loams (upland soils)	65.0	15	20	65
Clays	29.1	34	27	39
Sandy loams	8.2	5	20	75
Piedmont (Roanoke River Watershed outside the Dan River area)				
Fine sandy loams (bottomland soils)	12.7	11	18	71
Fine sandy loams (upland soils)	75.5	15	20	65
Clays	20.7	34	27	39
Clay loams	54.0	22	39	39
Sandy loams	9.1	5	20	75



E C-1
OF AGRICULTURE
TION SERVICE
T, CHIEF
RN REGION
L DIRECTOR
SAMPLE TRIBUTARIES,
RAINAGE BOUNDARIES
R WATERSHED
TH CAROLINA
20
30
40
MILES
N
80°
77°
37°
36°
BOTETOURT
LIMESTONE VALLEY
MOUNTA
Blacksburg
Lafayette
ROANOKE
Roanoke
MONTGOMERY
North Fork
South Fork
Back
Tinker Cr.
Beaverdam Cr.
Goose
Gills Cr.
Maggodee Cr.
Blackwater
Union Hall
Roanoke
FRANKLIN
Pigg
FLOYD
Rocky Mount
Chestnut Cr.
Snow Cr.
CARROLL
Philpott Dam
Smith
PATRICK
HENRY
North
South
River
Leatherwood
Sandy
Peter Cr.
Russell Cr.
Marrowbone
VIRGINIA
NORTH CAROLINA
LLE
Mount Airy
Francisco
STOKES
Mayo R.
Leaksville
River
Wolf Island Cr.
ROCKINGHAM
Dan
Town Fork Cr.
SURRY
YADKIN
FORSYTH
Winston-Salem
GUILFORD
VIRGINIA
NORTH CAROLINA
don
NORTH-HAMPTON
GATES
HERTFORD
COASTAL PLAIN
Scotland Neck
RIVER
BERTIE
Cashie
River
CHOWAN
MARTIN
WASH
arboro
ord
hen
ary.
dary
BEAUFORT
MD.
W. VA.
VIRGINIA
KY.
TENN.
NORTH CAROLINA
GA.
S. C.
LOCATION MAP
2-6-48


FIGURE C-1
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, CHIEF
SOUTHEASTERN REGION
T. S. BUIE, REGIONAL DIRECTOR
PHYSICAL LAND UNITS, SAMPLE TRIBUTARIES, AND MAIN STREAM DRAINAGE BOUNDARIES
ROANOKE RIVER WATERSHED
VIRGINIA - NORTH CAROLINA
SCALE OF MILES
Stream Gaging Station
Raintall Station with long-term record
Physical Land Unit Boundary
Main Stem Watershed Boundary, when used as an evaluation reach boundary.
Sample Tributary Watershed Boundary
LOCATION MAP
LIMESTONE VALLEY
MOUNTAIN-FOOTHILLS
PIEDMONT
PLATEAU
COASTAL PLAIN
VIRGINIA
NORTH CAROLINA
2-6-48

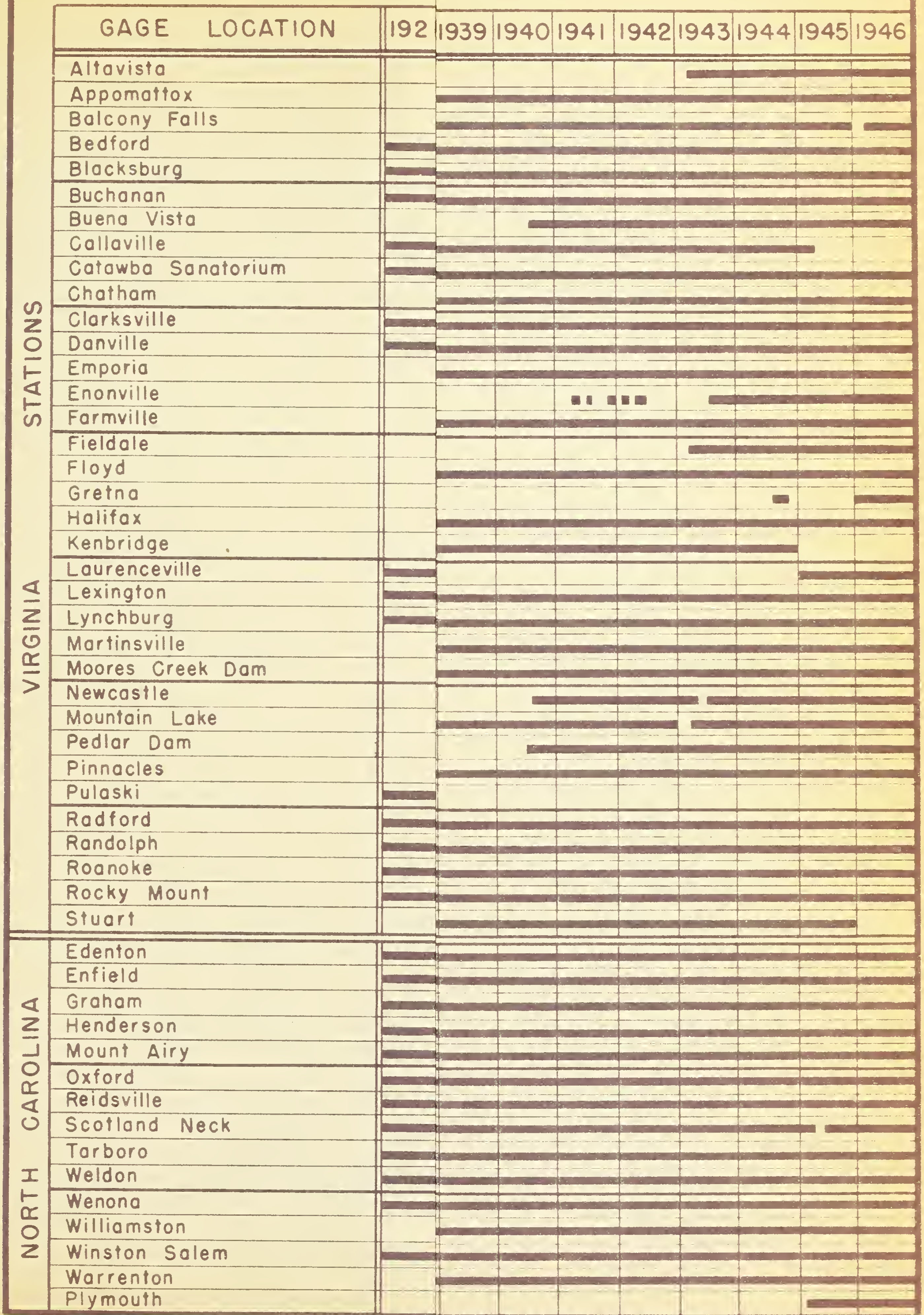
U S. DEPARTMENT OF AGRICULTU

ROANOKE RIVER WATERSHED

FIGURE C-2

RAIN GAGERIVER SURVEY

(Statinage Area)



PREPARED BY SOIL CONSERVA

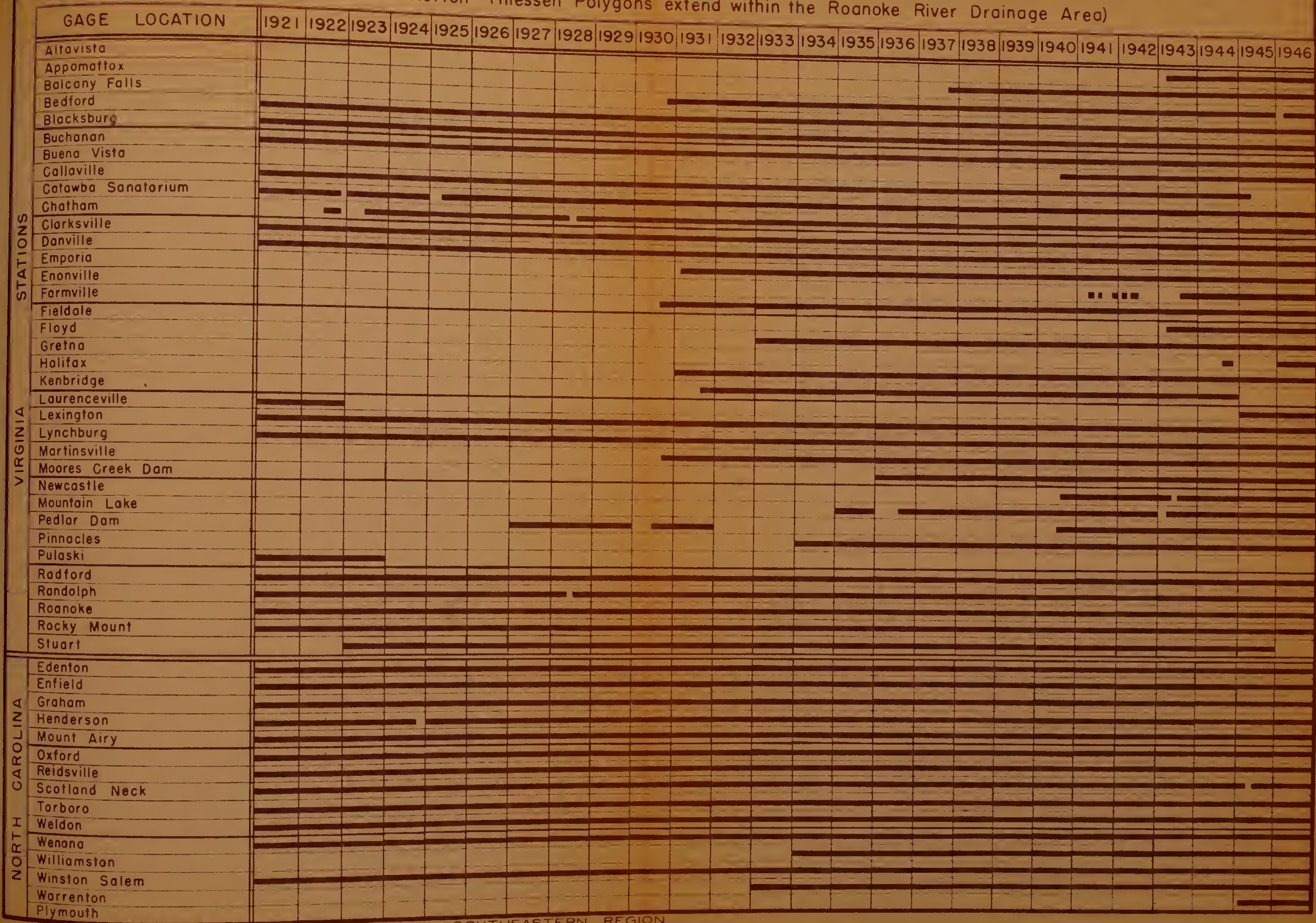
1948

U S DEPARTMENT OF AGRICULTURE

ROANOKE RIVER WATERSHED
FIGURE C-2

RAIN GAGE STATIONS 1921–1946 FOR ROANOKE RIVER SURVEY

(Stations whose Horton-Thiessen Polygons extend within the Roanoke River Drainage Area)



PREPARED BY SOIL CONSERVATION SERVICE,
H H BENNETT, CHIEF

SOUTHEASTERN REGION
T S BUIE, REGIONAL DIRECTOR

U.S. Department of Agriculture

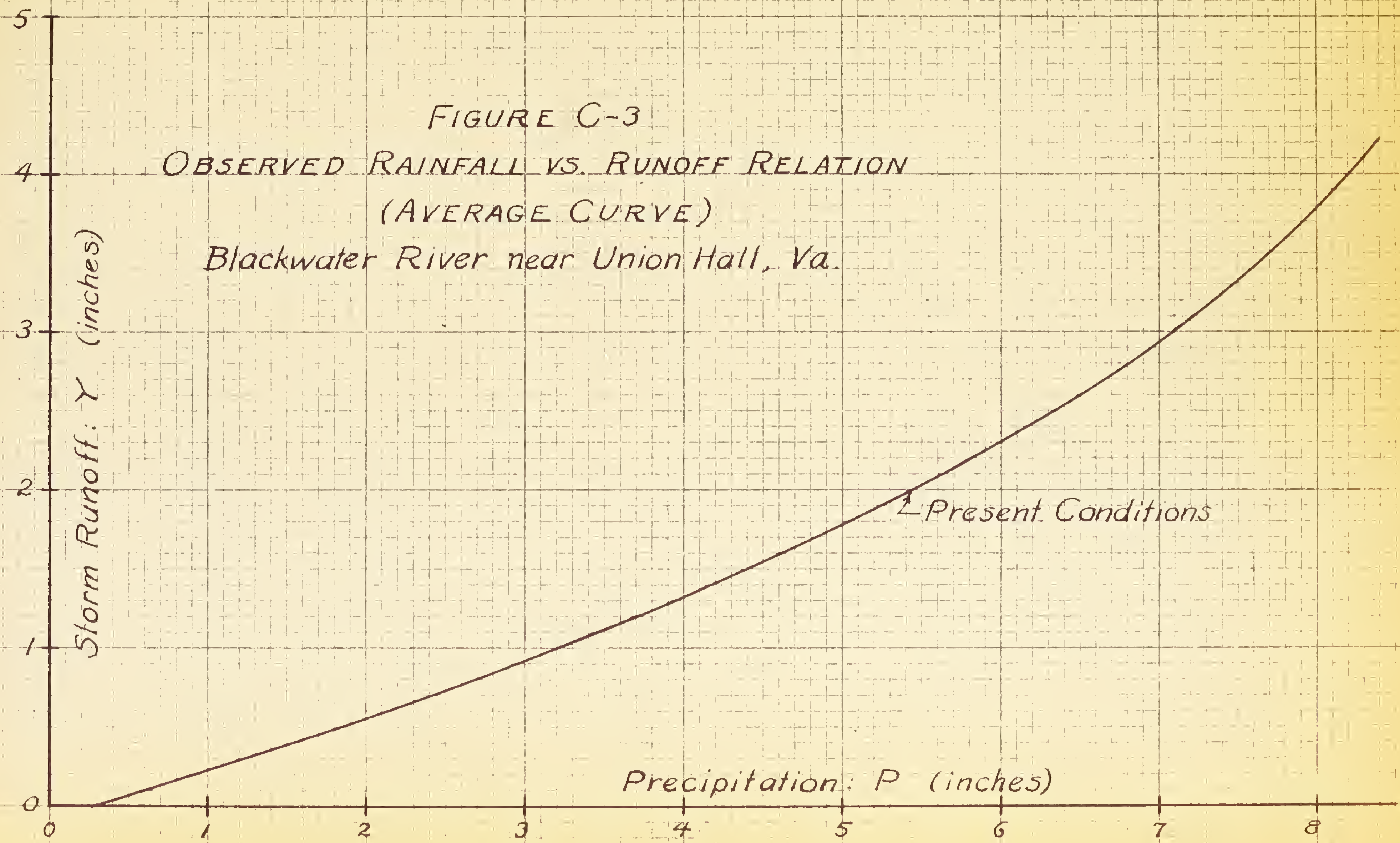
Roanoke River Watershed

FIGURE C-3

OBSERVED RAINFALL VS. RUNOFF RELATION

(AVERAGE CURVE)

Blackwater River near Union Hall, Va.



1949

Prepared by Soil Conservation Service, Southeastern Region
H. H. BENNETT, CHIEF
T. S. BUIE, REGIONAL DIRECTOR

FIGURE C-3

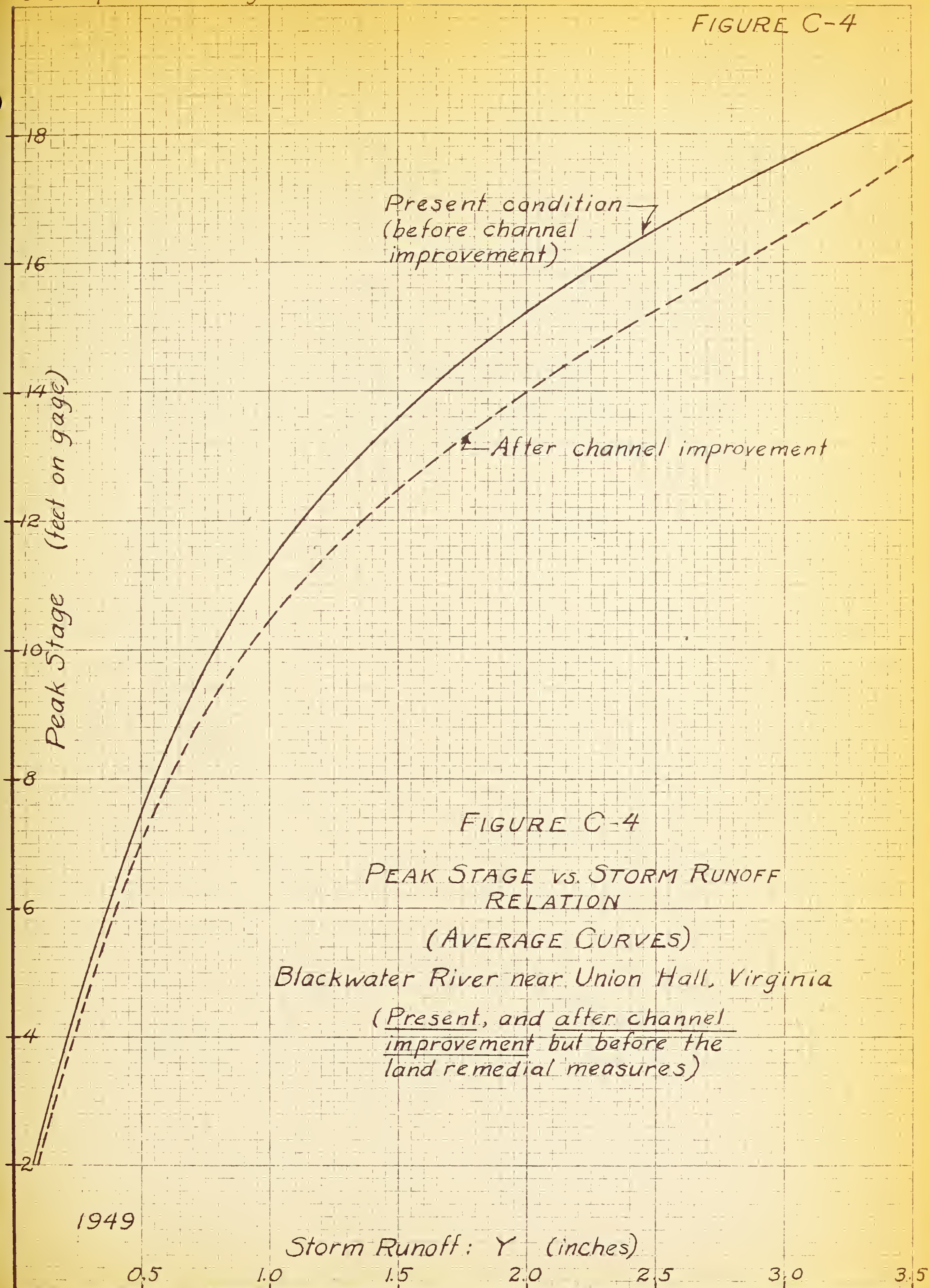
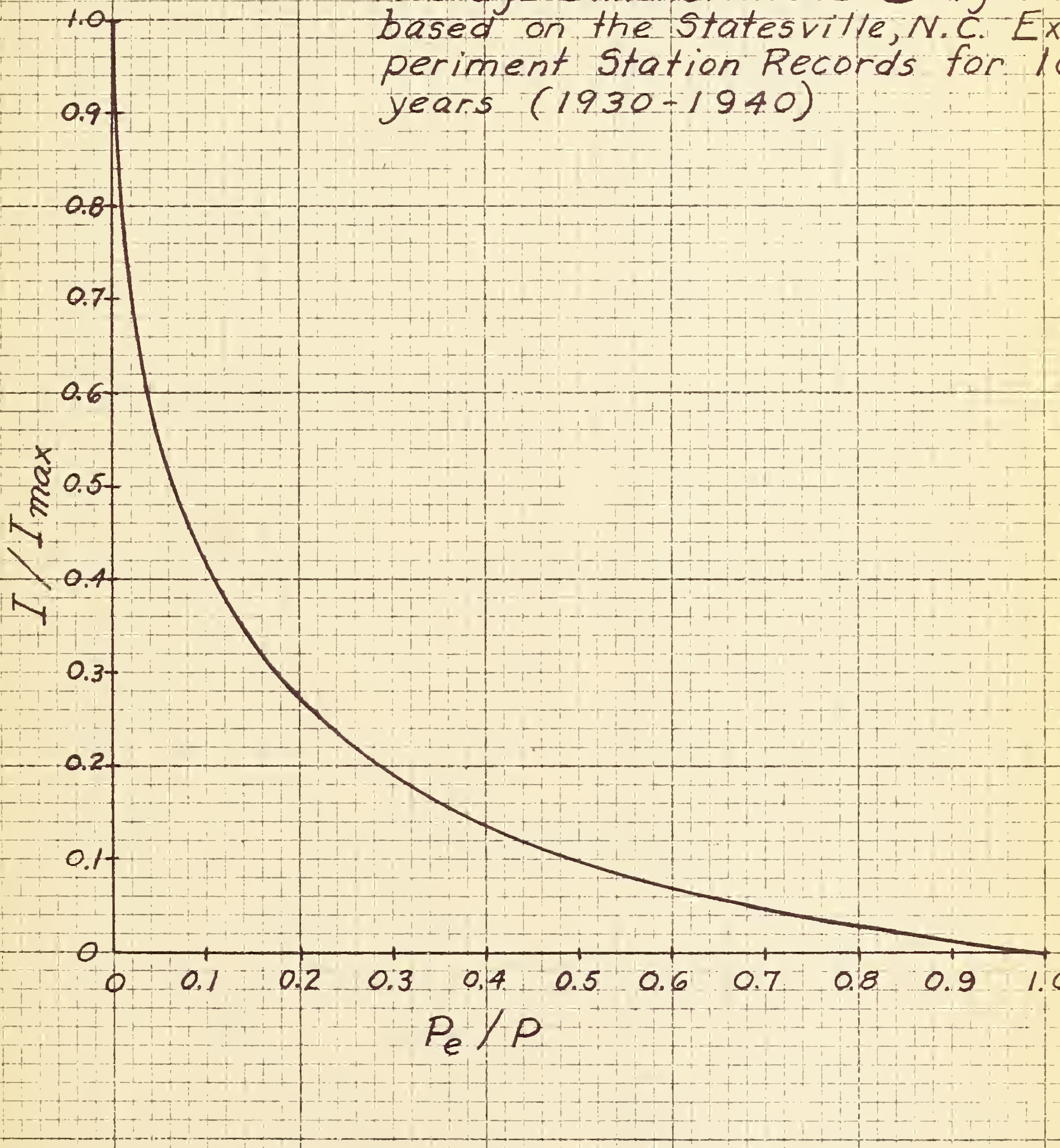


FIGURE C-4
Present condition (before channel improvement)
After channel improvement
Peak Stage (feet on gage)
18
16
14
12
10
8
6
4
2
FIGURE C-4
PEAK STAGE vs. STORM RUNOFF RELATION
(AVERAGE CURVES)
Blackwater River near Union Hall, Virginia
(Present, and after channel improvement but before the land remedial measures)
1949
Storm Runoff: Y (inches)
0.5
1.0
1.5
2.0
2.5
3.0
3.5

FIGURE C-5

DIMENSIONLESS DIAGRAM
I/I_{max} VERSUS P_e/P RELATION

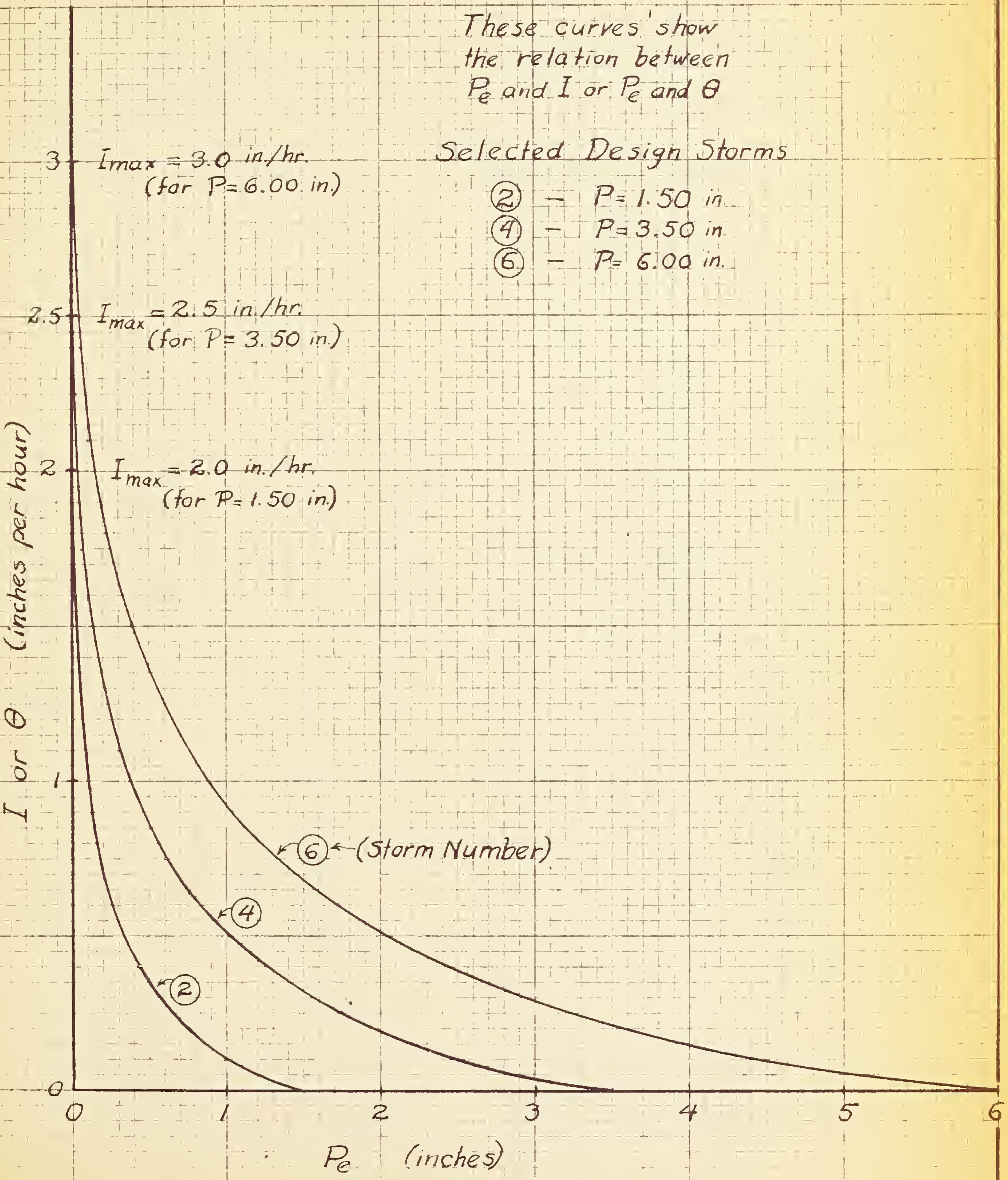
Average Dimensionless Diagram based on the Statesville, N.C. Experiment Station Records for 10 years (1930-1940)



1948-1949

FIGURE C-6

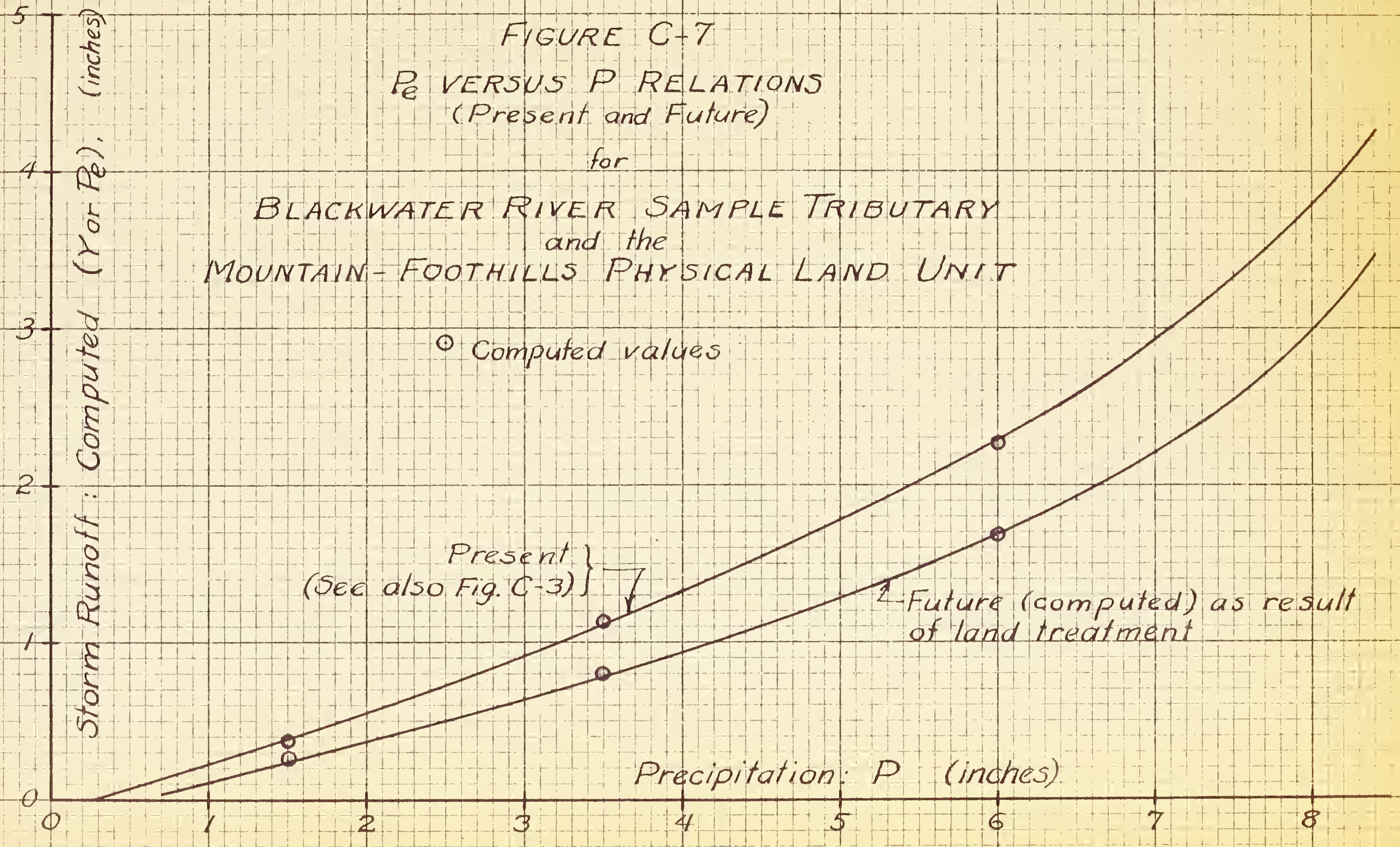
AVERAGE P_e CURVES FOR SOME SELECTED DESIGN STORMS
(Based on Statesville, N.C. Records)



1949

U.S. Department of Agriculture

Roanoke River Watershed



1949

FIGURE C-7

Prepared by Soil Conservation Service, Southeastern Region

H. H. BENNETT, CHIEF T. S. BUIE, REGIONAL DIRECTOR

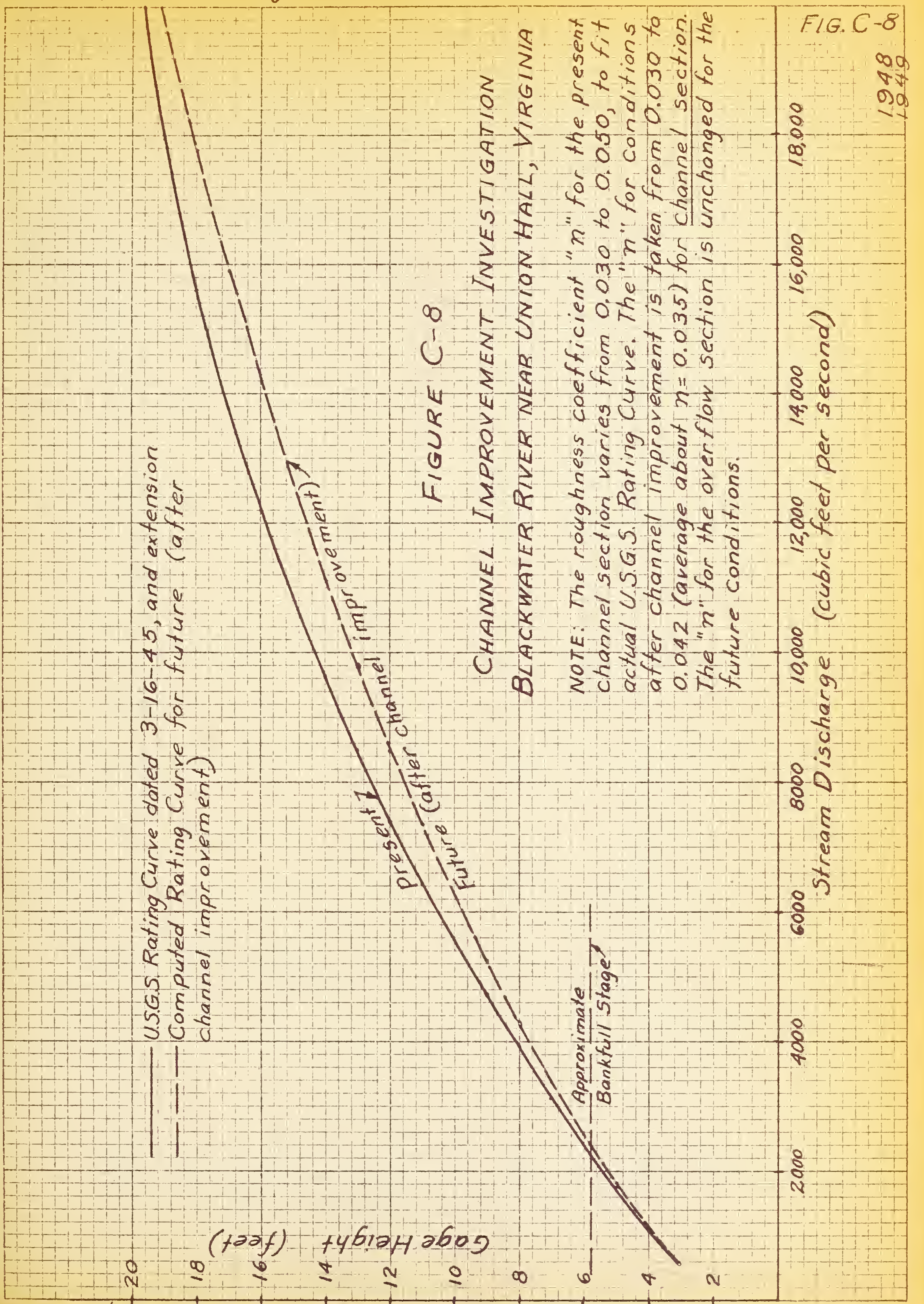


FIG. C-8
1948
1949
FIGURE C-8
CHANNEL IMPROVEMENT INVESTIGATION
BLACKWATER RIVER NEAR UNION HALL, VIRGINIA
NOTE: The roughness coefficient "n" for the present channel section varies from 0.030 to 0.050, to fit actual U.S.G.S. Rating Curve. The "n" for conditions after channel improvement is taken from 0.030 to 0.042 (average about n = 0.035) for channel section. The "n" for the overflow section is unchanged for the future conditions.
U.S.G.S. Rating Curve dated 3-16-45, and extension
Computed Rating Curve for future (after channel improvement)
present
future (after channel improvement)
Approximate Bankfull Stage
Gage Height (feet)
20
18
16
14
12
10
8
6
4
2
2000
4000
6000
8000
10,000
12,000
14,000
16,000
18,000
Stream Discharge (cubic feet per second)

FIGURE C-9

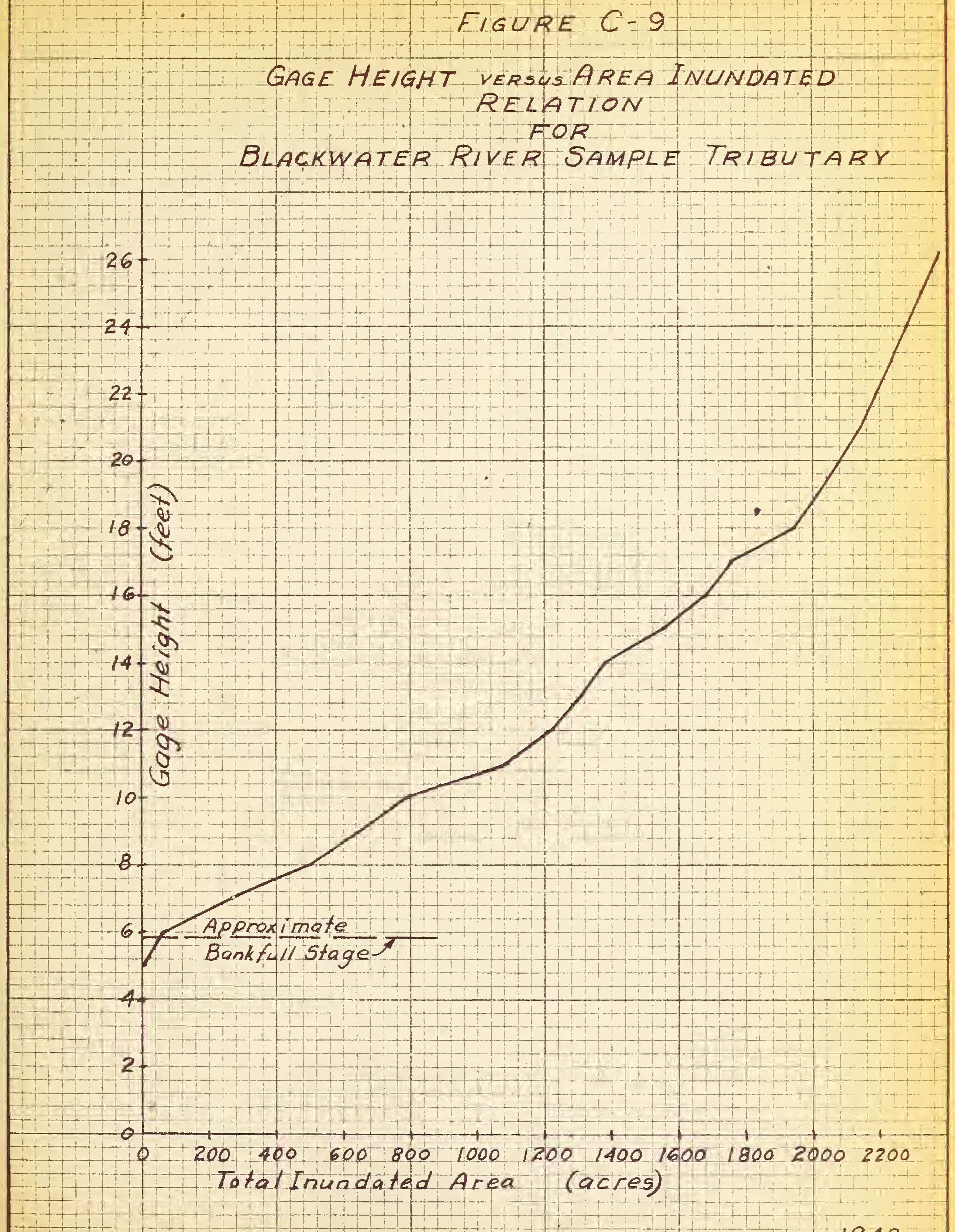
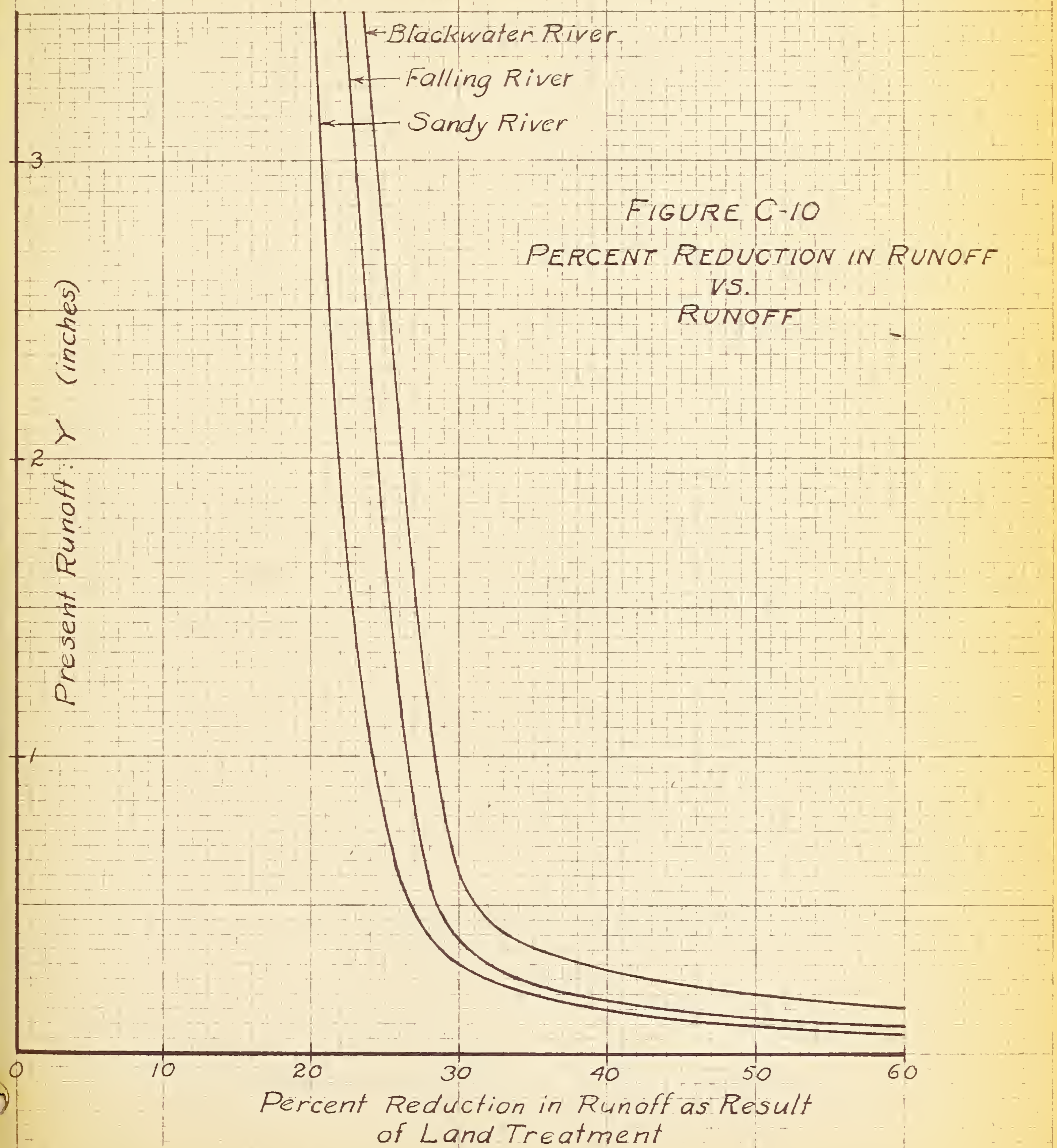


FIGURE C-9
GAGE HEIGHT versus AREA INUNDATED RELATION FOR BLACKWATER RIVER SAMPLE TRIBUTARY
Gage Height (feet)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
Approximate Bankfull Stage
Total Inundated Area (acres)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
1948
1949


Blackwater River
Falling River
Sandy River
FIGURE C-10
PERCENT REDUCTION IN RUNOFF
VS.
RUNOFF
Present Runoff: Y (inches)
3
2
1
0
10
20
30
40
50
60
Percent Reduction in Runoff as Result of Land Treatment

1949

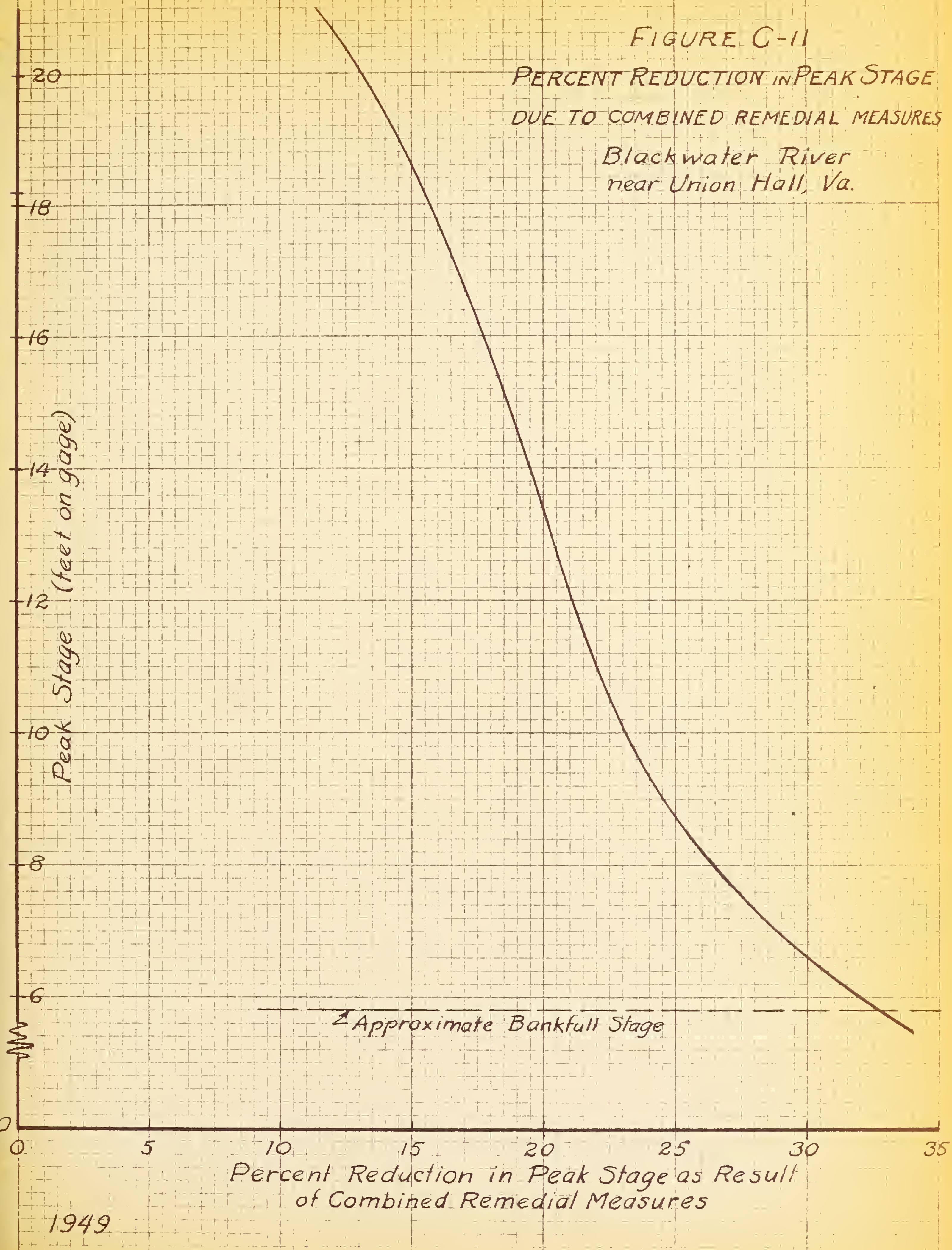


FIGURE C-11
PERCENT REDUCTION IN PEAK STAGE
DUE TO COMBINED REMEDIAL MEASURES
Blackwater River
near Union Hall, Va.
Peak Stage (feet on gage)
20
18
16
14
12
10
8
6
0
0
5
10
15
20
25
30
35
Approximate Bankfull Stage
Percent Reduction in Peak Stage as Result of Combined Remedial Measures
1949

APPENDIX D

DAMAGES, BENEFITS, AND COSTS

Table of Contents

TABLES

No.

FIGURES

SCOPE

Damage investigations on the Roanoke River watershed were conducted on sample tributary streams representing each of the physical land units. These investigations included: (1) direct floodwater and sedimentation damages, evaluated monetarily, which occur to crops, pastures, land, reservoirs, public water supply, railway and highway properties; (2) other direct damages, not evaluated monetarily, such as sediment damage to navigation, wildlife, aquatic life, and recreation; (3) other unevaluated damages such as loss of life and effect on public health and security; and (4) indirect damages, such as loss of employment or a business loss due to direct damages of an associated nature on the flood plain.

Since urban and industrial damages occur largely along the main stems and during high flood stages, no damage reductions are claimed for these types of damages. Therefore, no information concerning urban and industrial damages along the main stems appears in this report.

SUMMARY STATEMENT OF DAMAGES AND OFF-SITE BENEFITS

All floodwater and sedimentation damages and damage reductions, evaluated monetarily, are summarized in table D-1. Increased productivity of bottom lands due to channel improvement is shown in table D-18. The major damages are agricultural, and occur largely on tributary streams. The agricultural floodwater damages amount to about 67 percent of the total damages. Reductions in agricultural floodwater damages on flood plains of tributary streams range from 0 percent within the Limestone Valley area to 43 percent within the Mountain-Foothills area. All agricultural crop damage reductions, or benefits, amounted to about 53 percent of the total off-site benefits for the watershed. Table D-2 shows a summary of average annual agricultural damages and benefits on tributary streams and main stems by physical land units.

GENERAL PROCEDURE

All damage investigations in the field were conducted on sample tributaries. These sample tributaries and the physical land units which they represent are shown on figure C-1 in Appendix C. Aerial photographs and county highway road maps were used by technicians to locate points for study along the streams. The work of various members of the survey party was jointly planned and information exchanged during the course of field studies.

Reports by U. S. Corps of Engineers were used for estimates of agricultural damages on main stem. 1/

1/ Review report on Roanoke River, Va. and N. C., January 30, 1943.

The principal objective of field studies on damages was to obtain sufficient information on sample tributaries to form a basis for estimates of present and future annual damages.

Methods Used in Determining Floodwater Damages and Flood Control Benefits on Tributary Streams

Field Studies - A list of dated floods was made up before going to the field. Sufficient flood damage schedules were taken on each sample tributary to determine the usual land use and average yield of crops and pasture on the open flood plains. The amount of woodland within a flood plain was determined by planimetering on aerial photographs. The following information was also obtained in the field: Amount of damage for a given flood to dwellings, barns, farm roads, bridges, fences, and other fixed improvements within the flood plains on the farms; actual or percent damages to given crops per flood; loss of livestock and poultry, damages to machinery and equipment, indirect damages and non-monetary damages such as loss of life, illness and injuries due to floods. Information as to percent damage by depths of inundation by months for various crops was obtained from selected farmers and agricultural workers. Available data from local agricultural colleges and experiment stations on usual practices and costs of production, harvesting, and marketing of flood plain crops was supplemented as necessary by information obtained from farm operators along the sample tributary. The following is an illustration of land use data determined for each sample tributary.

Summary of land use on Falling River flood plain:

	Percent
Woodland	53.2
Pasture	7.5
Idle	6.1
Cropland	33.2
Hay (12.7 percent double cropped)	38.0
Corn	53.6
Small Grain	16.9
Dark Tobacco	2.8
Truck Crops	1.4

Damageable Values - Damageable value is the maximum loss that could accrue to one acre of specified crop by flooding during a given month. Damageable values per acre of specified crops were computed for each of the sample tributaries.

During the period of seedbed preparation, and up to the time when crops can no longer be replanted, the value represents the cost of labor, seed, fertilizer, and estimated crop loss due to late planting caused by flooding. At the period too late for replanting, the

total value of the undamaged matured crop less unexpended costs, was used. In the case of corn on Falling River flood plain, for example, preparation of the seedbed begins normally about March 15, planting begins May 1, and June 15 is considered too late for replanting. Harvesting begins about October 1 and is completed by November 15.

The following is given as an example of the analysis of cost per acre of producing crops (1946 prices):

Corn:	
Land preparation	$17.00
Planting	7.00
Cultivation	15.00
Harvesting	22.00
	$61.00

Note: These costs include land rent and use of buildings and equipment prorated on basis of time consumed by each operation.

A summary of the yields and gross value of crops grown on the Falling River flood plain in Virginia is given below:

Crop	Yield per acre	Gross value per acre
Corn	48 bu.	$79.00
Hay	1.85 tons	39.00
Small grain	wheat 20 bu.	
	oats 29 bu.	34.00
Dark tobacco	1000 lbs.	340.00
Truck crops	--	227.00

Flood damages on pasture were evaluated on basis of loss of grazing on old pastures. The estimated damageable values of crops and pasture on the Falling River flood plains are shown in Table D-3.

Percent Damage by Depths of Inundation - Estimates were obtained from selected farmers with considerable experience in growing crops on the flood plains on the percentage of damage resulting from floods of varying depths to various crops for each month of the year. The different estimates were adjusted to a reasonable figure for use in making estimates of damages per acre by depths of inundation for the various crops. These were combined to form a weighted average damage per acre for all crops by depths of inundation.

Table D-4 shows the estimated percent damage by depths of inundation for corn on Falling River flood plain.

Damage to Fixed Improvements - Estimates were obtained from farmers as to flood damages sustained to farm roads, fences, bridges, and drainage ditches for two or more floods of record. From this information, average annual damages of this type per stream mile were

developed and related to flood stage. These damages and damage reductions were included in agricultural damages.

Other Damages - Some damages occurred to livestock, poultry, and equipment, but were of a minor nature and infrequent occurrence; therefore, no estimate was made of them.

Occasional instances of loss of stock in a country store or damage to a grain mill occurred. Where these were of sufficient importance and of a recurring nature, they were included in the damage estimates.

Agricultural Damages and Benefits on Main Stems

Main stem damages were determined through use of data furnished by the Corps of Engineers, U. S. Army. Damages per stream mile for each of the main stem reaches were adjusted to 1946 price levels by use of farm price indexes. Average annual damages per stream mile were then recomputed for the reaches of the main stems which would be affected by the remedial program. All damages were excluded on main stem reaches and portions of reaches below Buggs Island and Philpott dam sites, as well as proposed reservoir areas inundated by these projects. In effect, this removed from consideration all damages occurring in the flood plain of the Smith River, all damages on the Roanoke River from its mouth to 56 river miles upstream from Buggs Island, and all damages on the Dan River from its mouth to 34 river miles upstream.

Benefits were estimated through a comparative analysis of the relationship existing between damage reductions on the main stem reaches and damage reductions on the tributaries by physical land units as determined on the Pee Dee River Watershed survey. A study of this relationship revealed a tributary damage reduction to main stem damage reduction ratio of 2.0 to 1.0 for the Mountain-Foothills physical land unit. Reductions for the Mountain-Foothills tributary streams in the Roanoke River Watershed amounted to 41 percent giving a corresponding expected reduction on the reaches of the main stems within the Mountain-Foothills area of the Roanoke River Watershed of 20.5 percent.

Stage-Damage Relationship by Months

Monthly stage-damage tables were prepared by combining the following factors to determine the total flood losses by foot intervals of stage covering the range of experienced flood heights:

a. Weighted average damage per acre by depth of inundation of all crops and pasture by months.
b. Range in flood stage covering the point where inundation starts, to maximum stage experienced.

c. Area of open land per stream mile inundated to various depths for one-foot intervals in flood stage.

To obtain the damage per stream mile for a given month and stage height, the areas inundated per stream mile at various depths of inundation for a given stage height were multiplied by the amount of damage per acre for the respective depths of inundation. The sum of these damages amounts to the damage per stream mile for a flood of given stage height. Stage-damage relationships for Falling River are shown in Table D-5.

Average Annual Damage per Stream Mile

Average annual flood damages per stream mile were computed for each sample tributary by obtaining the sum of the damages per mile resulting from each flood during the period of record and dividing by the number of years in the period.

Floods during the period of the record were listed chronologically. For each event of record, the cropland damage was obtained by reading directly from table such as Table D-5 and adjusting for sequent flooding.

Effect of Sequent Flooding

When more than one flood occurs within a given season of the year, all floods occurring after the first flood are called sequent floods. Each given sequent flood will do proportionately less damage to the acreage previously inundated than did any preceding flood of the season. At the same time, any area flooded for the first time by the sequent flood will sustain the same proportionate damage which would have occurred if the sequent flood had been the first flood of the season. Additional acreage is inundated by a sequent flood only when its peak stage is greater than the peak stage of any preceding flood in a given season.

Since damages were first computed for each flood separately as though each were the first flood of the season, it was necessary to recompute the damages sustained due to each sequent flood.

The following method was used in determining damages by sequent floods:

1. The year was divided into the following periods or seasons for purpose of determining damages by sequent floods: March, April and May; June, July and August; September, October and November; December, January and February.

   The damageable values and type of damage were very much the same for each month within a given season.

2. Open land area inundated per stream mile by each flood within a season.

Case:

a. First flood of the season, September 6, 1928, had a peak stage of 9.1 feet, inundating 11.4 acres open land per stream mile.

b. Second flood of the season, September 20, 1928, a sequent flood, had a peak stage of 11.6 feet, inundating 20.2 acres open land per stream mile.

c. Acres inundated in common by both floods are 11.4 acres per stream mile. Acres inundated for first time for this season by sequent flood are 8.8 acres per stream mile.

3. Determining the damage per acre by each flood, considering each flood as a first, or prime flood of the season.

a. Damage per acre for flood of September 6 amounts to $14.74 (damage per stream mile of $168 ÷ 11.4, number of acres inundated at stage 9.1 feet).

b. Likewise, the damage per acre for flood of September 20 amounts to $16.88.

4. Sequent damage by flood of September 20 on area inundated by both floods.

a. The maximum damage per acre possible for the month of September amounts to $21.76 (from table on damageable values per acre by months). Subtracting $14.74 (step 3a) from $21.76 gives $7.02, the remaining damageable value per acre after the first flood of the season.

b. If the flood of September 20 had been a first or prime flood of the season, the damage would have amounted to 77.6 percent of the total damage possible. (16.88 ÷ 21.76 = 77.6 percent).

c. The actual damage by flood of September 20 to area previously flooded on September 6 amounts to $5.45 per acre ($7.02 X 77.6% - $5.45).

d. The damage per stream mile for flood of September 20 on area inundated by both floods amounts to $62.13 ($5.45 X 11.4 No. of acres inundated by both floods).

5. Damage by flood of September 20 on area inundated for first time during season.

    a. The damage per stream mile amounts to $148.54. ($16.88 X 8.8. See steps 2c and 3b).

6. Total damage per stream mile by flood of September 20.

    a. The total damage per stream mile for sequent flood of September 20 amounts to $210.67, or approximately $211. ($62.13 ≁ $148.54. See steps 4d and 5a).

Some modification has been made of the above procedure to adapt it to varying situations, but the same general procedure was followed in estimating damages by sequent floods.

Damages to Roads and Railroads

Estimates were obtained from the state highway departments in Virginia and North Carolina on the annual flood damages occurring to roads and bridges within the Roanoke River Watershed.

Similar estimates were obtained for railroad property from officials of the Norfolk and Western and Southern Railway Companies.

A summary of the estimated damages and benefits on roads and railroads within the watershed is shown below.

Area	Annual damages		Annual benefits
	Present	Future	
	dollars	dollars	dollars
Limestone Valley	10,000	10,000	--
Mountain-Foothills	34,900	27,900	7,000
Piedmont Plateau	155,100	124,000	31,100
Coastal Plain	11,800	11,800	--
Total	211,800	173,700	38,100

DAMAGES NOT EVALUATED MONETARILY

Intangible Damages

Loss of life resulting from floods in the Roanoke River basin has been small. Four lives were lost in the August 1940 flood; three

in the Coastal Plain; and one in the Piedmont Plateau. Three lives were lost during the 1928 flood in the Piedmont Plateau area. Illness resulting from floods has been kept at a minimum due to prompt and effective action by national, state, and local agencies. Several thousand persons were inoculated by the North Carolina State Health Department following the 1940 flood. Four thousand persons were driven from their homes by the 1940 flood. 1/

Other Damages

Floods interrupt traffic and communication facilities of all kinds. Highways are inundated causing detours or suspension of vehicular traffic. In Roanoke, Virginia, 800 telephones went out of commission during the 1940 flood. Utility facilities are disrupted. Many hydroelectric plants cannot operate during high river stages. Public and industrial water supply systems are often forced to suspend operation during floods. At Weldon, N. C., during the 1940 flood, it was necessary to obtain the services of a U. S. Army portable filtration unit until the Weldon plant was brought back into operation. The water supply systems of 10 other cities and towns were affected by the same flood. 1/

There are additional extended damages not of a physical nature but still the result of floods. Such damages are loss of business, loss of wages, loss of rent, costs of relief and sanitation, and spread of noxious weeds. No attempt was made to evaluate these damages in monetary terms.

SEDIMENT AND RELATED DAMAGES TO FLOOD PLAINS

General Description

The area subject to sediment damage is not extensive in the Roanoke River basin. Above the Fall Line the topography shows evidence of recent uplift and subsequent rejuvenation, with the result that bottom lands are generally narrow and poorly developed. Flood plains make up 2.6 percent of the total land area in the Limestone Valley physical land unit, 3.5 percent in the Mountain-Foothills, and 4.3 percent in the Piedmont Plateau. The streams have high gradients and are actively cutting their channels. These characteristics while conducive to channel erosion and flood plain scour, preclude the possibility of extensive swamping damage. Below the Fall Line the topography is almost featureless. Within the Coastal Plain bottom lands are wide and make up approximately 50 percent of the total land area.

Channel fill was not extensive although it occurred locally. High gradients enabled most streams to maintain adequate channels. Normally stream beds are rock ledge, boulder or gravel. Channel studies

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1/ Roanoke River, Va. and N, C., Doc. No. 650, 78th C., 2nd S.,1944.

were made on all sample tributaries. Sandy River and Falling River, both located in the Piedmont Plateau, were the only sample streams having channel aggradation. There were no dredging operations in the watershed. Sand was pumped from the stream channels at a few places to be used for road material.

Swamping, brought about by channel fill and subsequent raising of the water table was of local importance. Some of the bottom lands along Countryline Creek in Caswell County, North Carolina, had been abandoned because of swamping. North Fork Goose Creek in the Mountain-Foothills physical land unit had almost complete channel fill in its lower reaches, and approximately 250 acres of bottom land were damaged by swamping. However, the aggregate damage from swamping for the watershed as a whole was small. Little or no swamping occurred on the tributaries or reaches used as samples, and no monetary damage was claimed from this source.

Stream bank erosion was of general occurrence although extensive damage occurred only during major floods. Most stream banks were grown up in trees and brush and protected from damage from the less severe storms. Bank erosion did not destroy a large acreage of bottom land, but occasionally was an important source of economic loss. There has been no noticeable widening of the channel section caused by stream bank erosion, either on the main reaches or tributaries.

Deposition of infertile sediments, principally sand, was of common occurrence throughout the entire area above the Fall Line. Most of the deposits occurred as natural levees adjacent to the stream channel.

Scour, the eroding of channels through the flood plain during periods of overflow, normally occurred near the channel in association with sanding. It was found along most streams above the Fall Line, but seldom caused serious damage.

The total area affected by sanding and scour was relatively small. These damages tend to recur in the same relative position on the flood plain, most often the area adjacent to the channel. The same area may be damaged and redamaged by succeeding floods. The sediment damage survey showed that about 22 percent of the total flood plain had been damaged during the 116-year period of accelerated erosion.

<u>Limestone Valley</u> - Land subject to sediment damage makes up 2.6 percent of the total land area in the Limestone Valley physical land unit. The streams are rapidly cutting their channels and have incised below the former valley level leaving a considerable area of terrace land which is no longer subject to overflow. Most of the bottom soils are well drained silt loams. There is little or no channel fill, and channel beds are either rock ledge or boulder. Damages from sedimentation are small. Ordinarily the stream banks are grown up in brush and sycamores. Much of the upland area is mountainous.

Approximately 1 percent of the total flood plain had been damaged by deposition. Scour had damaged 6.1 percent of the flood plain.

The sample used to represent the Limestone Valley was the Upper Roanoke River and its principal tributaries above the city of Roanoke, Va.

Mountain-Foothills - Deposition of sand on the flood plain causes most economic loss in the Mountain-Foothills physical land unit. Stream banks are normally heavily vegetated and protected from damage caused by minor floods. High stream gradients prevent excessive channel fill. There are occasional gravel bars, but they are migratory and temporary in nature.

Clear channels and good internal drainage have prevented serious swamping. The extreme headwater tributaries are characterized by high gradients, low banks, frequent gravel bars and poorly defined channels. Frequent overflow has caused numerous scour channels and sand and gravel deposits. These conditions are believed to be the result of early stages of normal valley development and are not caused by modern changes in runoff characteristics. The topography of the uplands is steeply rolling, hilly to mountainous. The area is highly wooded. Ridge tops are narrow and ridge sides steep. Sheet erosion is severe on the cleared areas. There are occasional shallow gullies. Deposition had damaged 5.5 percent of the flood plain and scour 2.9 percent.

The Blackwater River was the sample tributary used to represent this area.

Piedmont Plateau - Stream valleys in the Piedmont Plateau, particularly the upper portions, are generally narrow. In many places the valleys are little more than gorges. Even the main reaches of the Roanoke River have relatively narrow flood plains. Nearer the Fall Line, the uplands are not as steep and the valleys somewhat more mature. There are occasional low sand and gravel bars, but most of the streams are maintaining adequate channels. Channel studies made on the sample tributaries showed an average of 2 percent channel fill on Falling River and 14 percent fill on Sandy River. Swamping, a major source of damage in many parts of the Piedmont Plateau, is relatively unimportant in the Roanoke Watershed. No swamping occurred in the areas selected as samples, and no damage was claimed from this source. Deposition of infertile sediment accounted for most of the annual damage. Stream bank erosion was most severe along the main reaches of the Roanoke River and its principal tributaries. It was less common on the smaller streams. Bottom soils were inherently sandy. About 17.2 percent of the flood plain had been damaged by sanding. Scour had affected 3.8 percent of the bottom land.

The samples used to represent the Piedmont Plateau were Falling River, Sandy River, a reach of the Roanoke River below Altavista, Va., and a reach of the Dan River above Danville, Va.

Coastal Plain - With the exception of low sand hills near the Fall Line, the Coastal Plain physical land unit is a relatively flat area. Flood plains are wide. Large swamps are found in the lower part of the area. Most of the bottom soils are inherently wet and unfit for cultivation unless properly drained. Only a very small part of the flood plain is cultivated. Most of it is in woodland. Sand deposits occur along the main reaches of the Roanoke. This material is largely reworked sand from the channel and banks. There is little or no scour damage as most of the flooding is caused by backwater. Bank caving occurs along the main stem, but there is no important loss of bottom land acreage. Work on improvement of navigation channels by the Corps of Engineers indicated that the river was maintaining an adequate channel and was not filling to any serious extent.

Very little of the bottom land in the Coastal Plain physical land unit is in agricultural use. Sediment damage is of minor importance. No damage was found on Quankey Creek, the sample tributary.

Method of Making Sediment Damage Surveys of Flood Plains

At the beginning of the survey a reconnaissance was made of the entire watershed to determine the general extent and seriousness of the sedimentation problem. Following this, the sample areas were selected for detailed study. Detailed sediment damage surveys were made on sample tributaries and reaches within each physical land unit. Aerial photographs with a scale of 1 inch = 1320 feet were used as base maps. The purpose of this mapping was to show physical changes in the flood plain resulting from accelerated sedimentation. A three place symbol was used to show, in a roughly quantitative manner, the several types of sediment damage.

The first of these variables indicated the extent of modern deposits of infertile sediment on the flood plain, the second swamping and the third scour. The extent and amount of channel fill was determined by the engineering party in conjunction with their flood plain and channel cross section studies. Areas affected by bank erosion were outlined on the map.

The following legend was used in making the detailed sedimentation surveys:

Legend - Sediment Damage Survey

Deposition of Infertile Sediment

0 = No sediment deposits.
1 = 0-33% of area covered by sand to depths of 8" or more.
2 = 33 - 67% of area covered by sand to depths of 8" or more.
3 = 67 - 100% of area covered by sand to depths of 8" or more.

Swamping

1 = Bottom land formerly suitable for cultivation now suitable only for pasture.
2 = Bottom land formerly suitable for cultivation now suitable only for woodland.

Scour

0 = No scour.
1 = 0 - 33% of area scoured to depths of 12" or more.
2 = 33 - 67% of area scoured to depths of 12" or more.
3 = 67 - 100% of area scoured to depths of 12" or more.

Method of Calculating Damages and Benefits

The method used to calculate damages was based on determining a uniform annual increment of loss. Damage was considered as a loss of income and was based on rental values. The basic data used to determine amounts of sediment and related damages to flood plains were obtained from the detailed sedimentation surveys. The following procedure was used when calculating damages:

1. The survey maps were planimetered to determine the extent, in acres, of each type and intensity class of sediment damage.

2. Values were assigned to each damage class in order to convert physical damages to monetary terms. The annual loss of income resulting from the different types and degrees of damage was based on the landlords share of net rent on undamaged bottom lands within each physical land unit. These values were $29.52 for the Limestone Valley, $20.40 for the Mountain-Foothills, and $9.00 for the Piedmont Plateau. Stream bank erosion was considered as a total loss. The per acre value of the flood plain lands was $246.00 in the Limestone Valley, $170.00 in the Mountain-Foothills, and $75.00 in the Piedmont Plateau. The following table shows the annual per acre loss resulting from flood plain damage.

Loss of income resulting from flood plain damage

Type of damage	Damage class	Per acre loss	Annual per acre loss of income: Limestone Valley	Mountain-Foothills	Piedmont Plateau
		percent	dollars	dollars	dollars
Deposition	1	15	4.43	3.06	1.35
	2	45	13.28	9.18	4.05
	3	75	22.14	15.30	6.75
Scour	1	5	1.48	1.02	.45
	2	10	4.43	3.06	1.35
	3	25	7.38	5.10	2.25

3. The rate of loss (1947) was arrived at for each type of damage within the sample by multiplying the loss of income for each damage class by the number of acres within that class, Table D-6.

4. The only criterion of sediment damage was the condition of the flood plain at the time of the survey. The damage mapped represented the total cumulative loss up to the time of the survey (1947). In order to calculate annual increment of loss, it was first necessary to determine the number of years during which the loss had occurred. The mid-point between the beginning and peak years of agricultural development was used as the beginning of accelerated sediment damage. The number of years between this date and 1947, the year the sedimentation survey was made, represented the period of accelerated sedimentation damage. See table below.

Period of cumulative flood plain loss
Roanoke River Watershed

Physical land unit	Agricultural Development: Beginning	Agricultural Development: Peak	Sediment Damage: Median Pt. (Beginning)	Sediment Damage: Mapping
	year	year	year	year
Limestone Valley	1770	1905	1838	1947
Mountain-Foothills	1760	1905	1833	1947
Piedmont Plateau	1759	1903	1831	1947
Coastal Plain	1848	1897	1822	1947

	Years of cumulative loss
Limestone Valley	109
Mountain-Foothills	114
Piedmont Plateau	116
Coastal Plain	125

5. The annual increment of loss of income within the sample was determined by dividing the annual loss of income for the year of the survey (1947) by the number of years during which the accelerated sedimentation damage had been occurring. Table D-7.

6. The annual increment of loss of income was divided by the total number of acres within each sample to determine the annual per acre loss, Table D-7. This was done as a simple method of expanding damage figures from the sample tributaries and reaches to the entire watershed.

7. Damage was expanded from the sample to the entire watershed by multiplying the per acre annual increment of loss of income occurring within the sample by the total number of acres of flood plain for which the sample was considered to be representative, Table D-8. The area of flood plain affected by the Buggs Island and Philpott projects was not included with the watershed totals.

8. Estimates were made of the expected percent reductions in sediment damages resulting from the recommended program (see Effect of Recommended Program on Reduction of Sedimentation Damage, pages (20 - 22). The annual increment of loss with the program in effect was determined by using these percentage figures.

9. The annual equivalents of loss, with and without the program, were determined by multiplying by 24.505. This figure is the present value of an annuity of one per year for 100 years at 4 percent interest. In this calculation, it was assumed that the maximum extent of sediment damage to flood plains would be reached in 100 years.

10. The difference between the average annual equivalent of loss, without and with the program, was the average annual benefit, Table D-9. In the sample calculation given below the loss figure used is $2,005.22. This figure is the average annual increment of loss from deposition occurring in the Piedmont Plateau physical land unit

Sample Calculation

1. Average annual increment of loss without a program = $2,005.22

2. Average annual equivalent of loss without a program = $2,005.22 X 24.505 (present value of an annuity of one per year for 100 years at 4 percent interest) = $49,138

3. Average annual increment of loss with a program = $2,005.22 X 35 (program estimated to be 65 percent effective in reducing deposition damage) = $701.83

4. Average annual equivalent of loss with a program = $701.83 X 24.505 (present value of an annuity of one per year for 100 years at 4 percent interest) = $17,198

5. Average annual benefit = $49,138 - $17,198 = 31,940

SEDIMENTATION OF RESERVOIRS

General Description

The amount of storage capacity required as reserve to assure continuation of services during drought seasons of low inflow is the primary factor influencing the period of usefulness of water supply and storage type power reservoirs. Any decrease in active storage capacity because of sediment accumulation is a damage since such loss will shorten the useful life of the reservoir.

A majority of the reservoirs in the watershed are channel type built primarily for head. Storage is not important in the case of these run-of-the-river developments. Ordinary stream flow is usually sufficient to meet water demands. Sediment accumulations in such basins have little effect upon operation of the plant, consequently cannot be claimed as a damage.

The rate of storage loss in a reservoir is largely determined by the ratio between its storage capacity and the size of the area contributing runoff to the reservoir. It has been established that for the southeastern states an original storage capacity of more than 75 acre-feet per square mile of watershed should be obtained to have a reasonably low rate of silting. Reservoirs with less than 25 acre-feet per square mile of drainage area are likely to have exceptionally high rates of silting. 1/

All of the channel type and a number of the retention type reservoirs have considerably less than 25 acre-feet of storage per square mile of drainage area. They were all filled with sediment in a relatively short time or are now rapidly filling.

Of the reservoirs which will be benefited by the recommended program all but Roxboro City Lake have original storage capacities of 100 or more acre-feet per square mile of drainage area. Carvins Cove Reservoir has more than 1,100 acre-feet of storage per square mile.

There were very little reliable data from sedimentation studies made within the watershed. The only available detailed information was from a sedimentation survey of Roxboro City Lake, Roxboro, N. C., made in 1941 and a resurvey made in 1946.

1/ Brown, Carl B. The Control of Reservoir Silting, Misc. USDA Pub. No. 521, 1943.

The Department of the Army, Corps of Engineers, made studies of two reservoirs. A sedimentation survey was made of the Schoolfield Reservoir at Danville, Va., in October 1930. A survey of sediment deposits in Walnut Cove Reservoir was completed in April 1932. These reservoirs are not considered very suitable for detailed surveys because of their extremely small capacity-watershed ratios (4 and 2 acre-feet respectively, per square mile of drainage area). Turbidity measurements at the municipal filter plants at Danville, Va., and Weldon, N. C., were also available. These studies were subject to considerable error and were not used when determining annual rates of sediment production.

Silting of Power and Water Supply Reservoirs - There are 32 reservoirs in the watershed sufficiently important to be considered in this report. Table D-10 lists these reservoirs and Figure D-1 shows their location. There are 20 power reservoirs, 14 of which are channel type built primarily for head.

The Halifax, Martinsville and Walnut Cove power reservoirs are retention type structures. They are already so nearly filled with sediment that reduction of the rate of sedimentation resulting from the recommended remedial measures will come too late to be of any appreciable benefit. These three reservoirs have very small storage capacities per square mile of drainage area and high rates of sediment accumulation, Table D-11. Sedimentation will not completely destroy their usefulness, however, as they can continue in operation on run-of-the-river flow during all but dry seasons.

Four of the 10 water supply reservoirs are channel type built primarily for head. The others are retention reservoirs.

There are two recreational reservoirs. Their watersheds are almost entirely wooded and they represent a small initial investment.

A number of natural ponds is located in the Coastal Plain physical land unit. Several of these, in times past, have been dammed near their outlets to secure enough head to operate small mills. All but one or two are now breached and abandoned.

Only six of the reservoirs show any appreciable benefit from reduction of the rate of sedimentation. Of these six, all but Roxboro City Lake have very low annual rates of sediment accumulation and unusually long expected periods of usefulness. Carvins Cove Reservoir is the largest existing reservoir in the watershed and represents the greatest investment. Towns Reservoir is located immediately downstream from Pinnacles Reservoir so that sediment is contributed from only a small portion of its total watershed.

Investigations of reservoir sedimentation made in the Southeast show an average annual rate of sediment production of approximately 0.5 acre-feet for every square mile of drainage area. This rate (0.5

acre-feet per sq. mile of drainage area) was used when calculating the rate of storage loss for reservoirs having all or part of their watershed in the Piedmont Plateau physical land unit except for Roxboro City Lake. The more highly wooded Mountain-Foothills area has a lower rate of sediment production. The rate in this area was estimated at 0.4 acre-feet per square mile of drainage area.

Authorized Reservoirs

Construction of two multiple-purpose reservoirs by the Department of the Army, Corps of Engineers, has been authorized. Initial work has been started on both projects. The Buggs Island Reservoir, the larger of the two, is located on the Roanoke River in the lower portion of the Piedmont Plateau. Philpott Reservoir is located on the Smith River about 7 miles above Bassett, Virginia, in the Mountain-Foothills physical land unit. Pertinent data are given in Table D-11. Both reservoirs have large storage capacities per square mile of drainage area and extremely long expected periods of usefulness.

Method of Calculation

A straight line depreciation of investment method was used when calculating the annual rate of sediment damage. Benefits from the recommended program were determined by multiplying the difference in the annual rate of sediment accumulation with and without remedial measures (expressed in acre-feet), by the per acre foot cost of storage, Table D-12. The original costs of the reservoirs were brought up to current prices (1946) by using the Engineering News Record Construction Cost Index 1/ and Statistical Abstract of the United States, 1946. Reservoir trap efficiency was determined from a curve based on storage capacity per square mile of drainage area. 2/

It was assumed that replacement sites were available in all cases. This is a conservative method of determining replacement costs as almost invariably the best reservoir sites have already been utilized.

SILTING OF PUBLIC AND INDUSTRIAL WATER SUPPLY

Approximately nine and one-half billion gallons of surface water were treated for domestic and industrial use in the watershed during 1946. The cost of treating this amount of water (chemicals and labor only) was about $340,000.

Approximately one-fourth of the population and many industrial concerns depend on treated surface water for their water supply. Practically all the larger towns and industrial plants use treated surface water. The smaller towns depend largely on drilled wells. There are

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1/ Engineering News Record, February 20, 1947.
2/ Brown, Carl B., Transactions, Am. Soc. Civ. Engr. Vol. 109 (1944), p. 1083.

45 additional water supply systems in the watershed. Most of these utilize water from wells and springs which require only chlorination. A few other filtering plants, none of which treated more than 30 million gallons annually, were considered too small for evaluation.

Water demand and cost figures from nineteen plants were used when evaluating benefits from the recommended program. The largest single water user is the Riverside and Dan River Cotton Mills, Inc., at Schoolfield, Va. The mills are supplied by two independent filtering plants, the largest treating an average of 7 million gallons daily. The smaller plant furnished process water and filters but does not chlorinate its supply.

Roanoke, Va., the largest city in the watershed, obtains its water supply from six independent sources, only part of which is filtered. Crystal Spring, with a flow exceeding four million gallons per day, is an important source of supply. Carvins Cove Reservoir, a new reservoir put into production in 1947, is the major source of water. Two smaller reservoirs, Beaver Dam and Falling Creek, furnished approximately 20 percent of the total supply up to the time of the introduction of the Carvins Cove supply. Additional springs and wells also furnish part of Roanoke's water.

Records from the different plants show a constantly increasing water demand. Consumption figures from the Danville, Va., plant over a period of 39 years show an average annual increase in demand of 7 percent over the base year of 1906. The average increase in demand between 1945 and 1946, for all plants was approximately 6 percent. Demand has been unusually high during recent years.

Only three of the larger water supply systems use retention reservoirs. The majority of plants secure water directly from the Roanoke proper or from one of its major tributaries. In most cases, water is diverted directly from the channels to the plant by pumping or gravity flow. Water from these sources has a relatively high turbidity during most of the year.

Daily turbidity measurements taken from the raw water intake of the Riverside and Dan River Mills plant show a daily average of 253 parts per million for the 13-year period 1934-1947. These same records show that average turbidities during the summer months (May through September) are more than four times greater than at any other time during the year. Rainfall during this period is about 20 percent above the average for the year. This is the season of most intensive cultivation when soils are most susceptible to erosion.

Except in one or two cases, each water treatment plant was visited and the operator or manager interviewed. Reliable and comparable cost figures were difficult to obtain, particularly from the smaller plants. Very few of the plants had any detailed cost breakdown and

some had no cost accounting system at all. Additional information was obtained from the publication "Public Water Supplies in Virginia, Descriptions and Chemical Analyses, State Department of Health, 1939". The North Carolina State Department of Health receives periodic reports on consumption and cost of treatment from the different plants within the state. A copy of this material was obtained from Raleigh, North Carolina.

A curve showing the relation of amount of water treated to cost of treatment, Figure D-2, was used to determine unit costs for those plants having no cost records. The cost figures include only costs of chemicals and labor. The unit cost of water treatment varies widely for the different plants, depending on the amount of water treated, character and amount of suspended material, alkalinity, plant efficiency, pumping charges, and completeness of treatment.

The recommended program, by reducing stream turbidities, will result in a reduction in cost of water treatment. A large part of the damage to water supply is caused by sediments of colloidal size. Existing data indicate that about 90 percent of the fine suspended matter comes directly from erosion of the uplands. Except for very low turbidities (50-100 parts per million) studies show a direct relationship between turbidity and the amount of chemicals needed for treatment.1/ The largest saving will be in the use of chemicals, principally alum. Additional savings will be in labor and reduced filtering and wash water charges.

Previous studies show that a 10 percent saving will result from a program that is 25-30 percent effective in reducing sediment load. 1/ It is estimated that the recommended program will result in a 15 percent reduction in cost of treatment. This figure was used when calculating benefits from the land treatment measures. No account was taken of the expected increase in demand in future years.

The costs of treatment and benefits resulting from the recommended remedial measures are shown in Table D-13.

The steps used in the calculation were as follows:

1. Water treated annually (million gallons) X unit treatment cost per million gallons = annual cost of treatment, without program.

2. Water treated annually X unit cost of treatment with program.

3. Cost of treatment without program - Cost of treatment with program = annual benefit.

1/ Garin, Alexis N. and Forster, G. W. Effect of Soil Erosion on the Costs of Public Water Supply, USDA, SCS-EC-1, July 1940.

EFFECT OF THE RECOMMENDED PROGRAM ON REDUCTION OF SEDIMENT DAMAGE

Accelerated soil erosion and runoff brought about by man's cultural development and subsequent misuse of the land are the basic causes of sedimentation damage. The effectiveness of the recommended remedial measures will depend largely on the extent to which these measures reduce soil erosion and the volume and velocity of flood flows. Benefits from the program will be twofold: (1) reduction of damage by eliminating or lessening the causative agents; (2) improvement of the land on which the damage originates.

Flood plain damages are largely a product of the excessive volume and velocity of flood flows. Gullies are the principal source of the coarse grained sediments which cause deposition damage and channel fill.

A large part of sediment damage to reservoirs, water supply and aquatic life is caused by the finer sediments which are carried as suspended load. Most of the damage to water supply is from colloidal size sediments. Existing data indicate that about 90 percent of the fine suspended matter comes directly from erosion of the uplands. 1/

In this watershed, sediment is produced principally by sheet erosion, gullying, erosion of cut and fill slopes, stream channel erosion and flood plain erosion. Quantitative data on sources of sediment are limited. A survey of the watershed above the Lexington City Reservoir, Lexington, N. C. (Piedmont Plateau), showed that 38.2 percent of the total sediment produced was from sheet erosion; 37.2 percent came from land where both sheet and gully erosion were active; 5.9 percent from large linear gullies; 16.7 percent from land completely destroyed by gullying, although such land constituted only 1.7 percent of the watershed area. Roads produced 2 percent of the sediment. Of the total material washed from slopes 37.7 percent had been deposited in colluvial positions or on the flood plain, and 62.3 percent was contributed directly to the stream channel. Studies of the contribution of gullies to stream loads in the Brown Loam area showed that 63 percent of the gullies contributed their load directly to stream channels. Debris from 37 percent of the gullies was deposited as alluvial fans. 2/

Detailed sedimentation surveys of High Point Reservoir, North Carolina, and Roxboro City Lake, North Carolina (Piedmont Plateau), before and after conservation practices were put into effect, indicate that rates of reservoir silting can be reduced by about 35 percent by applying

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1/ Brown, Carl B., Protecting Municipal Watersheds in Southeastern States, Public Works, Vol. 76, No. 5, May 1946.

2/ Brown, Carl B., The Control of Reservoir Silting, Misc. USDA Pub. No. 521, 1943.

simple conservation practices on 20 percent of the watershed land. 1/ Average rates of storage loss in Newnan Reservoir, Georgia, were reduced by 62 percent after soil and water conservation practices had been put into effect. 2/

The recommended program is expected to be most effective in the Piedmont Plateau physical land unit. This area is the most highly developed agriculturally, has the most widespread and serious sheet and gully erosion, and produces the highest rates of runoff and sediment damage. Erosion and runoff control measures in this area will be more effective and have a wider application than in other parts of the watershed.

Some indication of the effectiveness of the program can be obtained from expected reductions of stage and area inundated. Stage reductions for the evaluation series of floods on the Blackwater River (sample tributary for Mountain-Foothills) average approximately 35 percent while the area inundated was reduced by 64 percent. Average stage reductions for the evaluation series of floods on the sample tributaries of the Piedmont physical land unit averaged about 25 percent. Area inundated was reduced by 69 percent. Expected stage reductions in the Mountain-Foothills are largely attributable to the recommended forest improvement program. Stage reductions were not calculated for the Limestone Valley.

Perhaps even more significant, from the standpoint of scour and deposition damage, are the expected reductions in the number of overbank flows. For the evaluation series of floods on the sample tributaries overbank flows will be reduced by 43 percent in the Mountain-Foothills, and 62 percent in the Piedmont Plateau.

The estimated percent reductions of sediment damage resulting from the recommended program are as follows:

Estimated reductions of sediment and related damages resulting from recommended program

	Percent reduction of sediment damage		
Type of damage	Limestone Valley	Mountain-Foothills	Piedmont Plateau
Silting of reservoirs	60	60	70
Silting of water supply	15	15	15
Deposition of infertile sediments	60	60	65
Scour	30	30	30
Stream bank erosion	30	30	30

1/ Brune, Gunnar M., Effects of Soil Conservation on Reservoir Sedimentation in the Southeast. Jour. Soil & Water Consv., Vol. 2, No. 2, April 1947. 2/ Brown, Carl B., Protecting Municipal Watersheds in Southeastern States, Pub. Wks., Vol. 76, No. 5, May 1946.

A summary of estimated sedimentation damages and benefits from the proposed remedial program is shown in the accompanying table.

Summary of sedimentation damages and benefits from the recommended program

Type of damage	Annual damage Present	Annual damage Future	Annual benefit
	dollars	dollars	dollars
Damage to flood plains	69,500	28,700	40,800
Silting of existing reservoirs	5,700	2,200	3,500
Silting of authorized reservoirs	80,900	24,700	56,200
Silting of water supply	339,100	288,300	50,800
Total	495,200	343,900	151,300

OTHER DIRECT SEDIMENTATION DAMAGES AND BENEFITS NOT EVALUATED QUANTITATIVELY

Effect of Sediment on Aquatic Life

Except in the headwaters the main reaches of the Roanoke and Dan Rivers are low grade fishing streams. Pollution and turbidities are such that only the more hardy species of rough fish can survive. Game fish persist in the headwaters and some of the tributary streams. Considerable meat fishing for such species as catfish, carp, and suckers is carried on locally. Better quality pan fish are caught in the tributary streams.

One of the most important spawning and nursery areas of the striped bass is in the vicinity of Weldon, N. C. A yearly catch of 539,900 pounds valued at $59,389 is almost entirely dependent on the Roanoke River spawning area for perpetuation. 1/

A Federal hatchery has operated at Weldon since 1884 to take advantage of the local concentration of ripe adult bass. Reduced turbidities and more adequate flows during the spawning season, resulting largely from construction of the Buggs Island Reservoir, will be of considerable benefit to this industry. The U. S. Department of Interior, Fish and Wildlife Service, has completed studies in connection with the Buggs Island and Philpott Reservoirs. 1/ 2/

1/ A report on fish and wildlife resources in relation to the Buggs Island Reservoir, Roanoke River Basin, USDI, Fish and Wildlife Service, May 1946.

2/ A report on fish and wildlife resources in relation to the water development plan for the Philpott Reservoir Project on Smith River, Va., Roanoke River Basin, USDI, Fish and Wildlife Ser., Nov. 1946.

No attempt was made to evaluate the effect of reduced sedimentation on fish and shellfish in the main reaches below Buggs Island dam and in Albemarle Sound. Completion of the Buggs Island project will prevent most of the sediment contributed from the area above the dam from moving any farther downstream.

The recommended program, by reducing stream turbidities, will increase fish values.

Sediment Damage to Drainage Channels

Additional benefits will accrue from reduced silting of drainage channels. However, benefits will be small because of the limited extent of drainage work. There are no large drainage projects in the watershed. A few farms, almost all of them in the Coastal Plain section, have fairly extensive drainage systems. Lack of maintenance is a universal problem and the majority of drainage channels fill up in a short time. Drainage engineers claim that most of the material causing filling of ditches is contributed either from the banks or from the surface of unimproved roads. Flooding is largely from backwater.

Sedimentation of Navigation Channels

Sedimentation of navigation channels in the Roanoke and Cashie Rivers is not a serious problem. The Roanoke River and its principal tributary, the Dan, were important arteries of traffic prior to the advent of railroads and highways. A decline in the use of these rivers began about 1840. Present river traffic is confined to the lower reaches. The following paragraph is from the report "Roanoke River, Va. and N. C., House Document 65, 74th Congress, 1st Session.

"The question of silt deposition in the navigation channel of the Roanoke River below Weldon is not a serious one. A channel was dredged through the bar at its mouth in 1931 and a recent survey (1933) shows that the river is maintaining this channel in a satisfactory condition. There is a natural channel of more than project depth from the mouth to Hamilton, 62 miles upstream, and no dredging has been done in this stretch. Between Hamilton and Weldon, considerable dredging was done during the period 1871-1905, but has been suspended since that time due to the decline of commerce. Indications are that little silt is deposited in the navigable channel below Weldon, especially in the section below Hamilton, and that the channel will maintain itself to depths sufficient for present and prospective commerce. A detailed study of silt deposition in the navigable section below Weldon was not warranted."

The total cost of the navigation project below Weldon, N. C., to June 30, 1947, was $604,344.22. The average annual maintenance cost between 1931 and 1947 was approximately $5,000. Total cost of the Cashie River project to June 30, 1947, was $55,797.66. Figures D-3 and D-4 are copies of project maps furnished by the District Engineers office, Department of the Army, Corps of Engineers, Wilmington, N. C.

The Buggs Island Reservoir, when completed, will prevent most of the sediment produced in the watershed above from moving any farther downstream. The annual saving in dredging costs resulting from the recommended program is not expected to be significant. No benefits were claimed from this source.

Effect of Sediment on Malaria Control

The incidence of malaria is very low at the present time. No drainage work, with the primary purpose of malaria control, has been undertaken in the Roanoke River Watershed. The following paragraph was taken from a letter written by Charles M. White, State Director of Malaria Control, North Carolina Board of Health, dated December 2, 1947.

"Malaria has reached a very low ebb in the state at this time. Our recent bloodslide surveys show almost no positives, and the report of cases and death by physicians is at the lowest in history."

Effect of Sediment on Recreational Values

The Roanoke River and its tributaries are not uitlized to any great extent for recreational purposes. High turbidities and pollution make the river unattractive for swimming and boating, and detract considerably from its aesthetic appeal. Clearer water will increase its recreational use. Reduction of stream turbidities will increase recreational attendance at public parks and other recreational areas. Concession receipts, license fees and other recreational revenue will be increased.

Sediment Damage to Growing Crops

A film of sediment is deposited on the foliage of forage crops that have been inundated by floodwaters. This condition makes them highly unpalatable and unsafe for grazing. Grazing on pastures thus damaged may be prevented until rains wash off the deposits or new growth occurs. Reducing the amount of sediment carried by floodwaters will reduce this type of damage.

Sediment Damage to Property

Sediment increases the total property damage caused by floodwaters. It also complicates and adds to the cost of cleaning up after floods subside. This type of damage will be lessened with a decrease in the amount of silt carried by floodwaters.

CONSERVATION BENEFITS AND COSTS

Woodland Benefits

Conservation benefits, resulting from the management of forest land for watershed protection, are based on growth estimates derived from the Forest Survey. The benefits were determined by calculating the difference between value of a yield without the recommended program and value of an increased yield with the program. The installation of the program will increase stumpage production and will also yield a greater proportion of higher value forest products.

Present annual yield in the watershed is the average of current growth rates weighted by forest types in the Piedmont and Mountain sections as reported by the Forest Survey. This is estimated at 35 cubic feet per acre per year. For the purpose of comparison, it is assumed that growth in the future will not be greater than it is at present whether the program is installed or not. Recent studies by the Forest Survey have given some indication that without the program growth might be less, in which case benefits with the program would be greater than those shown in this report. However, to be conservative, a constant rate has been used in the computations.

The estimated future yield with the program is based on growth rates which now prevail in saw timber stands. Average yield at culmination of the program on this basis is 70 cubic feet per acre per year.

The dollar benefits to be derived from increased volume and value for forest land were determined as follows: The average value of a cubic foot of wood was based on stumpage prices paid in 1946 for each of the various products, weighted by the percentage of each product to total production 1/. The future average value per cubic foot was determined in the same manner using the same stumpage prices but weighting by the expected percentage of each product to be produced in the future 1/. Converting factors used to bring the various products to a common unit of volume are shown in table D-19. The average value per cubic foot for current production thus obtained is $.0674 and for future production is $.0714.

The increased value per cubic foot expected under the program results from a higher percentage of better quality products.

The total value of the benefits to be acquired by landowners with and without the program are as follows:

Expected returns in the future without the program = 35 cubic feet at $.0674 per cubic foot = $2.359 per acre per year.

1/ Forest Survey, U. S. Forest Service

Expected returns with the program = 70 cubic feet at $.0714 per cubic foot = $4.998 per acre per year.

Comparison of expected returns from forest land with and without the recommended program

	Area	Annual value of yield per acre 1/	Total Annual Value 1/
	Acres	Dollars	Dollars
Without program	2,805,615	2.359	6,618,446
With program	3,154,797	4.998	15,767,675
Conservation benefit			9,149,229

1/ Based on 1946 prices.

The forest land area of 2,805,615 acres was used to compute anticipated returns from woodlands without a remedial program; whereas the total area of 3,154,797 acres in forest with the recommended program includes 181,020 acres of open lands converted to forest and 168,162 acres that will be adequately managed by "going" programs. The above areas are exclusive of the Coastal Plain.

The annual conservation benefit of $9,149,229 is the difference between expected returns "with the program" after it becomes fully effective and those "without the program." Some benefits will accrue shortly after beginning of the installation period; benefits will increase progressively from year to year, but full benefits will not be received from the program until about 40 years after the beginning of installation period. Since nearly all of the benefits will accrue to private landowners, a discount rate of 4 percent was used to determine present value of future benefits.

Total Cost of Forest Land Program

The estimated total cost of installing the recommended measures and practices on forest land is $9,404,800. In addition, operation and maintenance costs will begin with the first phases of installation of the program and will increase periodically until a maximum annual cost of operation and maintenance of $624,200 is reached at the end of the installation period. This amount will then continue after installation period as an annual operation and maintenance cost. The distribution of costs is shown in table D-14.

Total costs were estimated by applying unit costs of measures to the average quantities required. Soil Conservation Service and Forest Service operational records supplemented by information from other state and local agencies were used in determining unit costs.

Some of the considerations in the development of costs of the recommended program 1/ are:

1. Mountain watercourse control - As shown in table D-14, funds amounting to $300,000 are provided for installation of small headwater rock or brush dams, lead-off or diversion ditches, and similar devices, in combination with plantings of deep-rooted species along the channels and gullied tributaries of the Mountain-Foothills area to help reduce sediment movement, channel scour and bank cutting, and to retard flood flows. The measure will be maintained at a maximum average annual cost of $10,000. The Federal Government is expected to pay all costs of this measure.

2. Adequate fire control - An installation cost for additional fire control in North Carolina is estimated at 3.5 cents per acre per year over the 20-year installation period, or a total of $463,600 for the 662,300 acres of private forest land involved. It will cost 2.5 cents per acre, or a total of $16,600 annually thereafter for maintenance. Current expenditures of five cents per acre per annum in the rest of the watershed is now providing adequate protection. The Federal Government is expected to pay up to one-half of fire protection costs. Other public agencies pay the remaining costs of such protection.

3. Woodland management - The estimated total cost of installing the recommended forest land management measures is $5,167,800. Of this amount, $5,023,000 will be spent on private lands for technical services for grazing control and for stabilizing old logging roads and trails. The private share of this cost for work on private lands amounts to $1,252,100.

Maintenance of measures after the period of installation will involve technical services to be provided by public agencies and labor materials, and other contributions to be provided by private landowners. The maintenance cost is distributed about three-fourths to private with the remainder divided equally between Federal and state agencies.

4. Tree planting - The cost of establishing a forest cover on denuded forest land and on farm lands recommended for conversion to woodland, is about equally divided between the Federal Government and other participants. Public agencies will supply nursery stock and technical services. In addition, public aid payments are provided to cover about 50 per cent of the labor cost of planting on farm lands. The remainder of the labor cost is borne by the landowner.

5. Land acquisition - As shown in table D-14, funds are provided to purchase 70,000 acres. The cost of public acquisition, covering the cost of the land as well as the incidental expense of acquiring it, is estimated to be $6.80 per acre. Installation of necessary woodland management measures on these lands has been provided for under the woodland management item. Most of the acquisition as well as the woodland management installation costs are to be borne by state and other local public agencies. Maintenance after installation period of woodland management measures on land to be acquired is provided for with respect to non-Federal public land but not for Federal land.

1/ The recommended program is discussed in Appendix E.

Benefits and Costs of Open Land Measures

Local experiment station data, insofar as pertinent data were available, were used in estimating costs of producing various crops. These data were supplemented to include inputs of labor and materials under the recommended measures. Changes in normal expenses to farm operators were arrived at by applying current average production costs per acre to the number of acres of each important crop grown, present and future. Differences between present and future costs were listed as either increased or decreased costs of operation. Increased costs in farm operations were a result mainly of land conversions and increased acreages of summer and winter cover crops. Decreased costs in farm operations came about through reductions in costs of production of corn and cash crops due to soil improving rotations and other practices, and a subsequent reduction in acreage. A summary of changes in income and costs of farm operations is shown in summary below.

Benefits and Costs as Indicated by Change in Annual Gross Farm Income and Farm Operating Costs

Benefits: Increase in income and decreases in costs:

Limestone Valley	$2,432,000
Mountain-Foothills	7,608,000
Piedmont Plateau	48,262,000
Watershed total	$58,302,000

Costs: Decreases in income and increases in cost:

Limestone Valley	$1,025,000
Mountain-Foothills	3,733,000
Piedmont Plateau	22,772,000
Watershed total	$27,530,000 1/

Changes in gross farm income and changes in costs of farm operations resulting from the program were estimated on an areal basis in keeping with land use and crop changes recommended in each physical land unit area. Major land use and crop changes have been indicated in Appendix E. Estimates of increased yields due to the program were based on a study of local experiment station data, results of Soil Conservation Service studies and experience in similar areas on the benefits of conservation farming, and the judgment of members of the survey party. See table D-22 on estimated increases in yields of various crops per acre. Changes in gross income to farm operators were arrived at by application of current average prices to both

1/ 14.6 percent of this amount, or $4,019,400, was charged to the recommended program and the balance to the "going" program. See page D-33 for derivation of percentage.

present and future production by crops. As in costs, differences between present and future gross income were listed as either increased or decreased income.

In estimating costs and benefits of the farm land treatment measures, average prices paid and received by North Carolina and Virginia farmers for the year 1946 were used. These prices are itemized below.

Average prices paid by farmers in Roanoke River Watershed - 1946

Item	Unit	Price dollars
1. Farm labor (man)	Hr.	.50
2. Tractor and operator (including usual plowing and planting equipment)	Hr.	3.50
3. Tractor, combine and operator (including miscellaneous items)	Acre	5.12
4. Binding grain	Acre	3.00
5. Baling hay	Bale	.20
6. Horse labor (including usual plowing, planting cult., equip., etc.)	Hr.	.25
7. Fertilizers (includes delivery):		
3-9-6	Ton	34.00
3-12-6	Ton	37.00
4-10-6	Ton	37.50
4-12-4	Ton	37.50
2-12-12	Ton	39.50
0-14-7	Ton	32.50
3-8-5	Ton	32.00
2-12-6	Ton	33.50
5-10-5	Ton	39.00
10-6-4	Ton	44.00
Muriate of Potash	Ton	52.00
Nitrate of Soda	Ton	42.00
Superphosphate (20%)	Ton	23.00
Ammonium Sulfate	Ton	44.00
Bone Meal	Ton	53.00
Agr. Ground Limestone	Ton	3.60
Lime spreading	Ton	.75
8. Seeds and plants:		
Korean Lespedeza	Lb.	.10
Kobe Lespedeza	Lb.	.18
Sericea Lespedeza	Lb.	.26
Red Clover	Lb.	.50
White Dutch Clover	Lb.	1.00

Average prices paid by farmers in Roanoke River Watershed - 1946 (cont'd).

Item	Unit	Price
Ladino Clover	Lb.	2.50
Alfalfa	Lb.	.52
Soybeans: Oil	Bu.	3.00
Hay	Bu.	3.65
Cowpeas	Bu.	5.20
Crimson Clover	Lb.	.32
Ky. Blue Grass	Lb.	.62
Orchard Grass	Lb.	.30
Herds (Red Top) Grass	Lb.	.23
Timothy	Lb.	.12
Italian Rye Grass	Lb.	.13
Corn: Common	Bu.	2.00
Hybrid	Bu.	8.00
Cotton seed	CWT	6.50
Wheat	Bu.	3.10
Oats	Bu.	1.25
Irish Potatoes	Bu.	2.80
Peanuts	Lb.	.20
Kudzu	1000 plants	12.00
9. Pasture mowing charge (one mowing)	Acre	1.70

Average prices received by farmers in Roanoke River Watershed - 1946

1. Tobacco: Bright	Lb.	.4519
Dark	Lb.	.3405
2. Cotton: Lint	Lb.	.324
Seed	Ton	71.70
3. Corn	Bu.	1.65
4. Small Grain: Wheat	Bu.	2.01
Oats	Bu.	.97
5. Hay (all kinds - loose)	Ton	21.22
6. Alfalfa hay	Ton	27.56
7. Peanut vine hay	Ton	17.86
8. Peanuts	Lbs.	.102
9. Sweet Potatoes	Bu.	2.30
10. Irish Potatoes	Bu.	1.20
11. Apples	Bu.	2.48
12. Peaches	Bu.	2.15
13. Pasture rent	A.U. Mo.	1.50
14. Soybeans	Bu.	2.70
15. Snap beans	Bu.	1.71
16. Tomatoes	Bu.	1.55
17. Watermelons	Melons	.30
18. Squash	Bu.	1.00
19. Sorghum sirup	Gal.	2.10
20. Pecans, all	Lb.	.401

Benefits and Costs of Erosion Control Along Roads and Railroads

Eroded material washed down from unprotected roadway and railroad cuts and fills obstructs ditches and culverts. About one-third of the total cost of roadway maintenance is chargeable to the removal of this material. As time goes on, this debris is washed farther down causing sediment damage to flood plains and reservoirs. It may either be deposited on stream valleys as alluvial fans or carried directly to the stream channel where it contributes to sediment load.

Representatives of the State Highway Departments in Virginia and North Carolina were contacted and information obtained on cost per mile of repairing damage by erosion on principal highways, improved or soil type roads, and unimproved roads. Railroad companies operating within the watershed were also contacted for similar information on maintenance of railroad cut and fill slopes and side ditches. These cost figures were used as a basis for estimating maintenance cost due to erosion without a program. It was estimated the program would reduce these maintenance costs by 66 percent. These reductions in costs are claimed as conservation benefits.

The downstream benefits from roadway treatment are claimed under benefits to flood plains and reservoirs. Erosion control along highways and railroads was considered, along with other watershed treatment measures, in evaluating the effectiveness of the over-all treatment in reducing sediment damage.

A summary of estimated benefits of erosion control along roads and railroads is given below. The cost of the treatment is shown in table D-17.

	Annual cost of road maintenance due to erosion		Annual benefits
	Without program dollars	With program dollars	dollars
Limestone Valley	20,100	6,800	13,300
Mountain-Foothills	69,000	23,400	45,600
Piedmont Plateau	262,300	89,200	173,100
Total	351,400	119,400	232,000

SUMMARY OF BENEFITS AND COSTS OF PROGRAM MEASURES

General

Appraisal of the effects of the recommended program include: (1) benefits in reduction of damages caused by floodwaters, reservoir sedimentation; turbidity of public water supplies, damages to land by deposition, scouring and swamping, and increased production of land as a result of channel improvement and drainage; (2) soil and water conservation benefits accruing to farm owners and operators as a result of the program, reduction in maintenance costs on public roads and railroads due to erosion control and increased returns on woodlands as a result of fire control and better management; and (3) intangible and other benefits not evaluated monetarily.

The recommended program will reduce flood volume and peak discharge, thereby bringing about better regulation of stream flow and reduction of flood crests. The area inundated by floods of various magnitudes would also be reduced on different tributaries and reaches of the main stream. It is estimated that the rate of accelerated sheet and gully erosion will be reduced from 60 to 70 percent. In general, there will be no radical changes in cropping or type of farming due to the recommended program. The major land use changes proposed will result in conversion of idle and steep eroded cultivated lands to pasture, perennial hay or grazing crops and woodland.

The allocation of costs of the recommended measures to Federal, non-Federal public and private has been made on the basis of experience in the application of practices and measures similar to those recommended in this report.

Summary of Estimated Average Annual Benefits from "Going" and Recommended Programs

Reductions in floodwater damage:		
Agriculture	$523,200	
Roads and railroads	38,100	
Sub-total		$ 561,300
Reductions in sediment and land damages:		
Reservoir sedimentation	59,700	
Silting of water supply	50,800	
Land Damage	40,800	
Sub-total		151,300
Increased productivity of bottom land:		179,800
Total average annual flood control benefit:		892,400
Other benefits:		
Open land conservation	58,302,000	
Woodland	9,149,200	
Decreased maintenance costs on roads and railroads	232,000	67,683,200
Total average annual benefit		68,575,600

Assignment of Benefits to "Going" and Recommended Programs

The total benefits of the watershed treatment program amounting to $68,575,600 less benefits claimed for tributary channel improvement amounting to $358,700 leaves benefits amounting to $68,216,900, which are assigned to the land treatment measures. Benefits accruing from land treatment measures are divided between the "going" and recommended program in proportion to the annual costs of the two phases of the land treatment program. Separate comparisons are made for woodland and open land measures for assignment of conservation benefits.

Woodland Treatment Measures:

Annual equivalent costs "going" program	$ 24,000
Annual equivalent costs recommended program	863,500
Total	$887,500

$\frac{863,500}{887,500}$ = 97.3% to recommended program.

$9,149,200 annual woodland conservation benefits X 97.3% = $8,902,200 of these benefits assigned to recommended program.

Open Land Treatment Measures:

Annual equivalent cost of "going" program	$6,820,300
Annual equivalent cost of recommended program	1,168,400 1/
Total	$7,988,700

$\frac{1,168,400}{7,988,700}$ = 14.6% to recommended program.

$58,302,000 annual open land conservation benefits X 14.6% = $8,512,100 of these benefits assigned to recommended program.

Flood Control Benefits:

For the purpose of assigning a proportion of the flood control benefits to "going" programs, the combined annual costs of woodland and open land measures were used.

Annual equivalent costs land treatment "going" program =	$6,844,300
Annual equivalent cost of recommended land treatment program =	2,031,900
Total	$8,876,200

$\frac{2,031,900}{8,876,200}$ = 22.9% to recommended program.

1/ Includes prorated costs for facilitating services.

Reductions in floodwater damages amount to $561,300

$561,300 - $178,900 (benefits to channel improvement) =	$382,400
Reductions in sediment and land damages amount to	151,300
Total affected by "going" program	$533,700

533,700 x 22.9% = $122,200 of these flood control benefits assigned to recommended land treatment measures.

The annual equivalent costs used in apportioning benefits were determined by taking $2\frac{1}{2}$ percent of total Federal and non-Federal public installation costs and 4 percent of total private installation costs and adding annual maintenance costs.

A summary of benefits assigned to the recommended program is given below to show adjusted benefits by source.

Summary of Estimated Average Annual Benefits Assigned to Recommended Program

Reductions in floodwater damage:		
Agriculture	$ 257,800	
Roads and Railroads	8,700	
Sub-total		$ 266,500
Reductions in sediment and land damages:		
Reservoir sedimentation	13,700	
Silting of water supply	11,600	
Land damage	9,300	
Sub-total		34,600
Increased productivity of bottom land		177,800
Total average annual flood control benefit		478,900
Associated benefits:		
Openland conservation	8,512,100	
Woodland	8,902,200	
Decreased maintenance costs on roads and railroads	232,000	
Sub-total		17,646,300
Total average annual benefit		$18,125,200

In the calculation of benefits, future floodwater damages were not discounted due to any increase in flood plain area being damaged by sedimentation. The only significant sediment damages to land are from deposition. The expected increase in the area damaged by deposition will not result in any significant reduction in future floodwater damages.

Summary of Costs of Recommended Program

A summary of costs as taken from table D-14 is given in table D-15. These costs are grouped as follows:

	Annual costs
Land Treatment	
Federal and non-Federal public installation	$ 299,700
Private installation	172,100
Operation and maintenance	5,571,700 1/
Total	$6,043,500
Tributary Channel Improvement and Stream Bank Stabilization	
Federal and non-Federal public installation	75,600
Private installation	21,000
Operation and maintenance	154,100
Total	$250,700

The average annual equivalent of installation costs was determined by taking 2½ per cent of the total Federal and non-Federal public installation costs and 4 percent of the total private installation costs.

Comparison of Benefits and Costs

Tributary Channel Improvement and Stream Bank Stabilization - Damage reductions attributable to channel improvement were determined in the same manner as reductions due to the complete program. See table D-2. Floodwater damage reductions amounting to $178,900 plus increased productivity of bottom lands due to channel improvement amounting to $177,800 (table D-18), totaling $356,700 in benefits were compared to annual costs amounting to $250,700 at the 1946 price level.

To adjust these benefits and costs to prices expected to prevail under high level of employment conditions, the following indexes and conversion factors were used:

Name of Index	1946 Index	Projected Index	Conversion Factor
Prices Received, All Products	234	215	0.919
Prices Paid, Items Used in Production	191	205	1.073
Wage Rates	387	360	0.930
Construction Costs	346	424	1.225

The appropriate conversion factor was applied to each separable item of benefits and costs, and a properly weighted conversion factor to items which could not be readily separated. For example, flood reduction benefits to crops and pasture are composed primarily of costs during the first half of the year, but consist mostly of gross value less unexpected costs during the last half of the year. The

1/ Includes $4,019,400 added cost of operating farms.

conversion factor for prices received was used to adjust 50 percent of this benefit. As an average, labor accounts for about one-third of the cost of producing crops in this area, and items used in production account for the other two-thirds. Therefore, the wage rate factor (with a weight of 33 percent) was combined with the items used in production factor (with a weight of 67%) to determine the factor used on the other 50 percent of crop and pasture benefits.

The adjusted channel improvement benefits amount to $351,400, and the adjusted costs amount to $272,300, giving a benefit-cost ratio of 1.29 to 1.00 at prices expected to prevail under high level of employment conditions.

Complete Program - Using suggested high employment level conversion indexes provided by Bureau of Agricultural Economics, adjusted benefit and cost figures were obtained for benefit-cost comparison. Indexes used for conversions from 1946 prices are as follows:

Name of Index	1946 Index	Projected Index	Conversion Factor
Prices Received, All Products	234	215	0.919
Prices Paid, Items Used in Production	191	205	1.073
Wage Rates	387	360	0.930
Construction Costs	346	424	1.225
Wholesale Lumber	178	250	1.404

Total adjusted annual benefits amounting to $21,158,100 compared to total adjusted annual costs amounting to $6,583,900 give a benefit-cost ratio of 3.21 to 1.

Summary of Benefits and Costs at Adjusted Price Levels

	Average annual amount dollars	
Benefits:		
Flood control	484,500	
Associated	20,673,600	
Total		21,158,100
Costs:		
Federal	565,300	
Non-Federal public	361,300	
Private	5,657,300	
Total		6,583,900

Comparison of the Effect of Discounting Delayed Benefits

There are certain types of benefits resulting from the recommended program that will be delayed until treatment measures become fully effective. In this analysis, therefore, such benefits were discounted to allow for this lag in effectiveness.

It was assumed that benefits resulting from land treatment measures, namely, floodwater damage reductions, openland conservation benefits, and decreased cost of maintenance on roads and railroads, would be delayed 5 years; and that woodland conservation benefits would be delayed 40 years. It was also assumed that each type of benefit would start at zero and uniformly build up to the maximum over the period of delay. The benefits would then level off and remain constant thereafter.

Certain costs will also be delayed until treatment measures become fully effective. Increased costs of farm operations would be delayed 5 years. No delay is included for other costs.

Benefits resulting from the channel improvement measure will become fully effective immediately upon installation and, therefore, were not discounted.

Discounting deferred benefits and costs from land treatment measures will reduce the ratio of total benefits to total costs for all measures from 3.21 to 1 to 2.30 to 1.

The recommended program described and evaluated in these appendixes includes forest land management measures for 3,154,800 acres, the area which should be treated to achieve the most effective program of runoff and waterflow retardation and soil erosion prevention. An evaluation of the progress of the "going" program as it is now operating and as it is affected by the lack of some form of public control of forest practices on private land indicates that this full treatment will not be fully attained during the 20-year installation period.

In order to make the program consistent with these indications, the recommendations presented in the report include forest land measures for only the area on which it is estimated these measures will be installed and maintained. The quantities of forest land measures recommended in the report were obtained for estimating the percentage of accomplishments to be secured without some form of public control of forest practices on private forest land. These percentages, applied to the various practices included in the improved forest management measure for private forest land, reduced the area to be treated to 2,356,000 acres and reduced the installation cost from $5,167,800 to $4,177,400. The Federal Government will pay approximately $2,376,200 of the reduced cost, other public agencies $769,900, and private individuals $1,031,300. The annual operation and maintenance cost will be reduced from $597,600 to $387,900. Of the latter amount the Federal Government will pay about $94,300, other public agencies $90,500, and private individuals about $203,100.

Tree and shrub planting was also revised and is now recommended on 147,200 acres at an estimated installation cost of $1,336,800 to the Federal Government, $562,300 to other public agencies, and $803,200 to private individuals.

These changes resulted in a reduction of 28 percent in the average annual cost of the forest land program and 4 percent reduction in total annual cost of the land treatment program. These percentage reductions were applied to the benefits derived from the total forest land program and resulted in the following changes:

1. Reduction in flood and sedimentation damage due to recommended land treatment measures, shown on page 34, was reduced from $122,200 to $117,300.

2. Total woodland production benefits, shown on page 34, were reduced from $8,902,200 to $6,409,600.

The net effect on the annual cost and benefits of the land treatment measures, as shown on pages 34 and 35, is a change in installation costs from $471,800 to $435,000, a change in annual maintenance costs from $5,571,700 to $5,362,000, and a change in benefits from $17,768,500 to $15,271,000.

Total costs and benefits based on projected high employment level prices changed respectively from $6,583,900 to $6,309,900 and $21,158,100 to $17,653,200. The revised benefit-cost ratio for the entire recommended program is thereby changed from 3.21 to 1 to 2.80 to 1. Discounting delayed costs and benefits further reduces the benefit-cost ratio to 2.11 to 1.

Table D-1.

Area	Agri- cultur ds	Reservoir sedimen- tation 2/	Total	Percent reduction in damage
	dollars	dollars	dollars	
Tributaries:				
Limestone Valley	4,9	5,800	6,400	12.0
Mountain-Foothills	726,000	7,400	330,900	41.3
Piedmont Plateau	620,800	97,300	356,300	29.9
Coastal Plain	--	--	--	--
Main Stem:				
Roanoke River	49,5	--	10,700	21.6
Dan River	38,3	--	8,300	21.7
Total	1,439,500	110,500	712,600	33.2

1/ Includes added water treatmen

2/ Includes reductions in water

Table D-1.--Average annual damages and benefits by physical land units and main stem reaches
Roanoke River Watershed

Area	Damages					Benefits					Percent reduction in damage
	Agri-culture	Land	Roads and railroads	Reservoir sedimen-tation 1/	Total	Agri-culture	Land	Roads and railroads	Reservoir sedimen-tation 2/	Total	
	dollars	dollars	dollars	dollars	dollars	dollars	dollars	dollars	dollars	dollars	
Tributaries:											
Limestone Valley	4,900	1,500	10,000	36,900	53,300	--	600	--	5,800	6,400	12.0
Mountain-Foothills	726,000	12,100	34,900	27,600	800,600	310,300	6,200	7,000	7,400	330,900	41.3
Piedmont Plateau	620,800	55,900	155,100	361,200	1,193,000	193,900	34,000	31,100	97,300	356,300	29.9
Coastal Plain	--	--	11,800	--	11,800	--	--	--	--	--	--
Main Stem:											
Roanoke River	49,500	--	--	--	49,500	10,700	--	--	--	10,700	21.6
Dan River	38,300	--	--	--	38,300	8,300	--	--	--	8,300	21.7
Total	1,439,500	69,500	211,800	425,700	2,146,500	523,200	40,800	38,100	110,500	712,600	33.2

1/ Includes added water treatment costs.

2/ Includes reductions in water treatment costs.

Table D-2.--Average annual damages and benefits, tributary streams and main reaches
Roanoke River Watershed

Physical Land Unit	Stream miles	Damages		Benefits to channel improvement	Damages with complete program	Benefits with complete program
		Without program	With channel imp.			
		dollars	dollars	dollars	dollars	dollars
Tributary streams						
Limestone Valley	141	4,900	4,900	--	4,900	--
Mountain-Foothills	804	726,000	619,100	106,900	415,700	310,300
Piedmont Plateau:						
Roanoke River area	1,125	409,500	376,900	32,600	325,100	84,400
Dan River area	1,095	211,300	171,900	39,400	101,800	109,500
Sub-total	3,165	1,351,700	1,172,800	178,900	847,500	504,200
Main stems						
Roanoke River		49,500			38,800	10,700
Dan River		38,300			30,000	8,300
Sub-total		87,800			68,800	19,000
Total for watershed		1,439,500	1,172,800	178,900	916,300	523,200

Table D-3

WEIGHTED AVERAGE DAMAGEABLE VALUES PER ACRE BY MONTHS AND BY CROPS[1]
FALLING RIVER, VIRGINIA
ROANOKE RIVER WATERSHED

Crop	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec. Jan. & Feb.
						Dollars				
Corn	--	5.67	20.33	43.00	57.00	57.00	57.00	38.00	4.75	--
Hay	4.75	14.25	19.00	19.00	20.00	10.00	--	--	--	--
Small Grain	26.00	26.00	26.00	17.33	--	--	1.67	13.34	23.75	26.00
Dark Tobacco	--	7.00	51.38	98.12	226.50	212.67	77.34	--	--	--
Truck Crops	--	12.00	31.08	108.17	152.25	21.75	--	--	--	--
Pasture	--	0.74	1.47	1.76	0.95	0.88	0.96	0.59	--	--
All Open Land	4.40	9.50	17.56	26.38	33.26	28.97	23.56	16.14	4.66	3.12

1/ Based on 1946 prices and costs.

Table D-4

ESTIMATED PERCENT DAMAGE BY DEPTHS OF INUNDATION
BY MONTHS FOR CORN, FALLING RIVER FLOOD PLAIN
ROANOKE RIVER WATERSHED

Depth Inundation Feet	Month								
	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec. Jan.&Feb.
1	0	10	36	8	5	5	0	0	0	0
2	0	10	36	68	10	10	5	3	1	0
3	0	10	36	75	60	60	50	33	4	0
4	0	10	36	75	100	100	100	67	8	0
5	0	10	36	75	100	100	100	67	8	0
6	0	10	36	75	100	100	100	67	8	0

Table D-5

STAGE-DAMAGE RELATIONSHIPS BY MONTHS PER STREAM MILE 1/
FALLING RIVER FLOOD PLAIN
ROANOKE RIVER WATERSHED

Peak Stage 2/	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec. Jan.&Feb.
Feet	Dollars									
15	14	42	72	47	63	42	8	2	3	3
16	25	75	129	154	117	79	20	7	5	5
17	41	127	223	276	249	186	84	45	13	9
18	46	146	262	388	361	291	185	111	22	10
19	50	161	293	441	474	399	268	177	31	11
20	64	206	374	513	607	511	377	233	41	14
21	74	239	432	622	686	574	419	258	46	16
22	77	251	458	697	767	651	488	303	52	17
23	80	264	484	733	863	743	580	363	60	17
24	82	272	501	759	917	793	632	397	65	18
25	84	278	512	778	943	817	654	411	67	18
26	85	284	523	794	969	840	675	424	69	19
27	91	302	557	832	1,020	882	704	442	72	20
28	97	321	589	877	1,058	911	720	451	74	21
29	103	340	623	931	1,108	953	747	468	77	23
30	107	357	657	1,006	1,209	1,047	836	525	85	23

1/ Damages to crops and pasture; based on 1946 costs and prices.
2/ Stage in feet on the Falling River gage near Naruna, Virginia.

Table D-6

Physical land unit	Sample tributaries and reaches				Total	Stream bank erosion	
			3				
		rs	Acres	Dollars	Dollars	Acres	Dollars
Limestone Valley	Upper Roanoke River	27	35	258.30	1,107.41	5	147.60
Mountain-Foothills	Blackwater River	2	3	15.30	500.82	29	591.60
Piedmont Plateau	Falling River	00	11	24.75	78.30	0	.00
Piedmont Plateau	Sandy River	00	0	.00	145.80	16	144.00
Piedmont Plateau	Main Reach Dan River	40	6	13.50	151.65	24	216.00
Piedmont Plateau	Main Reach Roanoke River	25	0	.00	221.40	84	756.00

1/ Based on 1946 values.

Table D-6.--Loss of net rental value, sample tributaries and reaches 1/
Roanoke River Watershed

Physical land unit	Sample tributaries and reaches	Total acres in sample	Deposition of infertile sediment						Total	Scour						Total	Stream bank erosion	
			1		2		3			1		2		3				
			Acres	Dollars	Acres	Dollars	Acres	Dollars	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars	Dollars	Acres	Dollars
Limestone Valley	Upper Roanoke River	2,044	27	119.61	27	358.56	4	88.56	566.73	8	11.84	189	837.27	35	258.30	1,107.41	5	147.60
Mountain-Foothills	Blackwater River	2,802	13	39.78	190	1,744.20	68	1,040.40	2,824.38	5	5.10	157	480.42	3	15.30	500.82	29	591.60
Piedmont Plateau	Falling River	703	14	18.90	68	275.40	12	81.00	375.30	59	26.55	20	27.00	11	24.75	78.30	0	.00
Piedmont Plateau	Sandy River	1,386	16	21.60	271	1,097.55	337	2,274.75	3,393.90	324	145.80	0	.00	0	.00	145.80	16	144.00
Piedmont Plateau	Main Reach Dan River	2,255	0	.00	102	413.10	203	1370.25	1,783.35	295	132.75	4	5.40	6	13.50	151.65	24	216.00
Piedmont Plateau	Main Reach Roanoke River	2,142	32	43.20	200	810.00	503	3,395.25	4,248.45	387	174.15	35	47.25	0	.00	221.40	84	756.00

1/ Based on 1946 values.

s 1/

Physical Land Unit	of Loss		Annual Per Acre Increment of Loss		
		Stream Bank Erosion	Deposition	Scour	Stream Bank Erosion
	rs	Dollars	Dollars	Dollars	Dollars
Limestone Valle	16	1.35	.0025	.0050	.0007
Mountain-Foothi	39	5.19	.0088	.0016	.0019
Piedmont Platea	68	.00	.0046	.0010	.0000
Piedmont Platea	26	1.24	.0211	.0009	.0009
Piedmont Plateau	31	1.86	.0068	.0006	.0008
Piedmont Plateau	91	6.52	.0171	.0009	.0030

1/ Based on 194

al
of

Table D-7

ANNUAL INCREMENT OF LOSS OF NET RENTAL VALUE, SAMPLE TRIBUTARIES AND REACHES 1/
ROANOKE RIVER WATERSHED

Physical Land Unit	Sample Tributaries and Reaches	Total Acres in Sample	Loss Of Net Rental Value			Period During Which Loss Occurred	Annual Increment of Loss			Annual Per Acre Increment of Loss		
			Deposition	Scour	Stream Bank Erosion		Deposition	Scour	Stream Bank Erosion	Deposition	Scour	Stream Bank Erosion
			Dollars	Dollars	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Limestone Valley	Upper Roanoke River	2,044	566.73	1,107.41	147.60	109	5.20	10.16	1.35	.0025	.0050	.0007
Mountain-Foothills	Blackwater River	2,802	2,824.38	500.82	591.60	114	24.78	4.39	5.19	.0088	.0016	.0019
Piedmont Plateau	Falling River	703	375.30	78.30	.00	116	3.24	.68	.00	.0046	.0010	.0000
Piedmont Plateau	Sandy River	1,386	3,393.90	145.80	144.00	116	29.26	1.26	1.24	.0211	.0009	.0009
Piedmont Plateau	Main Reach Dan River	2,255	1,783.35	151.65	216.00	116	15.37	1.31	1.86	.0068	.0006	.0008
Piedmont Plateau	Main Reach Roanoke River	2,142	4,248.45	221.40	756.00	116	36.62	1.91	6.52	.0171	.0009	.0030

1/ Based on 1946 values.

Physical Land Unit	Sampl and	ream Bank Erosion r Acre	Total	Total Annual Increment of Loss
		ollars	Dollars	Dollars
Limestone Valley	Uppe	.0007	5.12	59.99
Mountain-Foothills	Blacl	.0019	76.35	494.29
Piedmont Plateau	Fall	.0000	.00	376.75
Piedmont Plateau	Sand	.0009	52.33	1,331.52
Piedmont Plateau	Main L	.0008	20.40	209.10
Piedmont Plateau	Main R	.0030	51.84	362.88
Total For Piedmont Pl			124.57	2,280.25
Grand Total			206.04	2,834.53

Table D-8

ANNUAL INCREMENT OF FLOOD PLAIN LOSS, ENTIRE WATERSHED
ROANOKE RIVER WATERSHED

Physical Land Unit	Sample Tributaries and Reaches	Total Flood Plain Area	Annual Increment of Flood Plain Loss						Total Annual Increment of Loss
			Deposition		Scour		Stream Bank Erosion		
			Per Acre	Total	Per Acre	Total	Per Acre	Total	
		Acres	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Limestone Valley	Upper Roanoke River	7,315	.0025	18.29	.0050	36.58	.0007	5.12	59.99
Mountain-Foothills	Blackwater River	40,186	.0088	353.64	.0016	64.30	.0019	76.35	494.29
Piedmont Plateau	Falling River	67,275	.0046	309.47	.0010	67.28	.0000	.00	376.75
Piedmont Plateau	Sandy River	58,145	.0211	1,226.86	.0009	52.33	.0009	52.33	1,331.52
Piedmont Plateau	Main Reach Dan River	25,500	.0068	173.40	.0006	15.30	.0008	20.40	209.10
Piedmont Plateau	Main Reach Roanoke River	17,280	.0171	295.49	.0009	15.55	.0030	51.84	362.88
Total For Piedmont Plateau		168,200		2,005.22		150.46		124.57	2,280.25
Grand Total		215,701		2,377.15		251.34		206.04	2,834.53

Table D-9.--Flood plain losses and benefits from recommended program
Roanoke River Watershed

Physical land unit	Type of damage	Average annual increment of loss: Without program	Average annual increment of loss: With program	Average annual equivalent of loss: Without program	Average annual equivalent of loss: With program	Average annual benefit
		Dollars	Dollars	Dollars	Dollars	Dollars
Limestone Valley	Deposition	18.29	7.32	448	179	269
	Scour	36.58	25.61	896	628	268
	Bank erosion	5.12	3.58	125	89	36
Mountain-Foothills	Deposition	353.64	141.46	8,666	3,466	5,200
	Scour	64.30	45.01	1,576	1,103	473
	Bank erosion	76.35	53.45	1,871	1,310	561
Piedmont Plateau	Deposition	2,005.22	701.83	49,138	17,198	31,940
	Scour	150.46	105.32	3,687	2,581	1,106
	Bank erosion	124.57	87.20	3,053	2,137	916
	Total	2,834.53	1,170.78	69,460	28,691	40,769

Physical Land Unit	Reservoir Name and/or Own	Principal Use	Primary Purpose	Remarks
	American Viscose Corp.(Up	ocess Water	Head	1/
	American Viscose Corp.(Lo	ocess Water	Head	1/
Limestone Valley	Appalachian Electric Powe	ensing Water	Head	1/
	Appalachian Electric Powe	wer	Head	1/
	Carvin Cove Falls	ter Supply	Retention	2/
	Beaver Dam	ter Supply	Retention	2/
	Bedford (Upper)	ter Supply	Retention	3/
	Bedford (Lower)	ter Supply	Retention	3/
	Fairystone State Park	creation	Retention	3/
	Falling Creek	ter Supply	Retention	2/
Mountain-Foothills	Hanging Rock	creation	Retention	3/
	Joyces Mill	wer	Head	1/
	Little Dan River	wer	Head	1/
	Niagara	wer	Head	1/
	Pinnacles	wer	Retention	2/
	Rocky Mount	wer	Head	1/
	Towns	wer	Retention	2/
	Stuart	wer	Head	1/
	Halifax	wer	Retention	4/
	Leaksville Cotton Mills	wer	Head	1/
	Martinsville	wer	Retention	4/
	Mayodan (Upper)	wer	Head	1/
	Mayodan (Lower)	wer	Head	1/
	Patterson Mills Co. Inc.	wer	Head	1/
Piedmont Plateau	Schoolfield (R.&D.R.C.M.)	ter Supply	Head	1/
	Riverside & Dan River Co	wer	Head	1/
	Riverside & Dan River Co	wer	Head	1/
	Roxboro	ter Supply	Retention	2/
	Roanoke Rapids	wer	Head	1/
	Spray	wer	Head	1/
	Walnut Cove	wer	Retention	4/
	Weldon	wer	Head	1/

1/ Filled to normal channel capacity.
2/ Will be benefited by program.
3/ Low rate of silting, highly foreste
4/ Will be filled before program becon

TABLE D -10

RESERVOIR INVENTORY
ROANOKE RIVER WATERSHED

Physical Land Unit	Reservoir Name and/or Owner	Stream	Nearest Town	Drainage Area Sq.Miles	Original Surface Area Acres	Original Storage Capacity Acre Ft.	Principal Use	Primary Purpose	Remarks
Limestone Valley	American Viscose Corp.(Upper)	Roanoke River	Roanoke, Va.	389.0	Small	Small	Process Water	Head	1/
	American Viscose Corp.(Lower)	Roanoke River	Roanoke, Va.	389.0	Small	Small	Process Water	Head	1/
	Appalachian Electric Power Co.(U)	Roanoke River	Roanoke, Va.	388.0	Small	Small	Condensing Water	Head	1/
	Appalachian Electric Power Co.(L)	Roanoke River	Roanoke, Va.	511.0	Small	Small	Power	Head	1/
	Carvin Cove Falls	Carvin Creek	Roanoke, Va.	18.0	630	19,948	Water Supply	Retention	2/
Mountain-Foothills	Beaver Dam	Beaver Dam Cr.	Roanoke, Va.	1.7	125	1,381	Water Supply	Retention	2/
	Bedford (Upper)	Stony Creek	Bedford, Va.	7.0	Small	Small	Water Supply	Retention	3/
	Bedford (Lower)	Stony Creek	Bedford, Va.	1.5	Small	Small	Water Supply	Retention	3/
	Fairystone State Park	Smith River	Fairdale, Va.	21.0	141	Small	Recreation	Retention	3/
	Falling Creek	Falling Creek	Roanoke, Va.	1.5	21	261	Water Supply	Retention	2/
	Hanging Rock	Trib.of Dan R.	Danbury, N. C.	0.6	12	Small	Recreation	Retention	3/
	Joyces Mill	Dan River	Mt. Airy, N. C.	105.0	Small	Small	Power	Head	1/
	Little Dan River	Dan River	Mt. Airy, N. C.	118.0	Small	Small	Power	Head	1/
	Niagara	Roanoke River	Roanoke, Va.	511.0	70	Small	Power	Head	1/
	Pinnacles	Dan River	Stuart, Va.	33.0	165	8,035	Power	Retention	2/
	Rocky Mount	Pigg River	Rocky Mount, Va.	50.0	Small	Small	Power	Head	1/
	Towns	Dan River	Stuart, Va.	32.9	40	1,380	Power	Retention	2/
	Stuart	S.Mayo River	Stuart, Va.	34.0	Small	Small	Power	Head	1/
Piedmont Plateau	Halifax	Banister River	Halifax, Va.	520.0	400	5,000	Power	Retention	4/
	Leaksville Cotton Mills	Dan River	Spray, N. C.	1,150.0	Small	Small	Power	Head	1/
	Martinsville	Smith River	Martinsville, Va.	374.0	200	1,200	Power	Retention	4/
	Mayodan (Upper)	Mayo River	Mayodan, N. C.	374.0	Small	Small	Power	Head	1/
	Mayodan (Lower)	Mayo River	Mayodan, N. C.	374.0	Small	Small	Power	Head	1/
	Patterson Mills Co. Inc.	Roanoke River	Rosemary, N, C.	8,395.0	Small	Small	Power	Head	1/
	Schoolfield (R.&D.R.C.M.)	Dan River	Danville, Va.	1,877.0	540	4,000	Water Supply	Head	1/
	Riverside & Dan River Cotton Mills	Dan River	Danville, Va.	2,049.0	300	Small	Power	Head	1/
	Riverside & Dan River Cotton Mills	Dan River	Danville, Va.	2,049.0	Small	Small	Power	Head	1/
	Roxboro	Satterfield Cr.	Roxboro, N. C.	7.5	65	531	Water Supply	Retention	2/
	Roanoke Rapids	Roanoke River	Roanoke Rapids, N.C.	8,395.0	45	Small	Power	Head	1/
	Spray	Smith River	Spray, N. C.	545.0	20	Small	Power	Head	1/
	Walnut Cove	Dan River	Walnut Cove, N.C.	397.0		1,654	Power	Retention	4/
	Weldon	Roanoke River	Weldon, N. C.	8,437.0	Small	Small	Power	Head	1/

1/ Filled to normal channel capacity.
2/ Will be benefited by program.
3/ Low rate of silting, highly forested.
4/ Will be filled before program becomes effective.

Re	ed rate ment ion per mi. of e area	Annual rate of sediment accumulation	Total loss of storage to date	Cost per acre foot of storage
	ft.	acre ft.	percent	dollars
Be		0.67	.01	197.09
Ca		7.06	--	103.11
Fa		.57	1.1	700.43
Ha		127.40	68.8	171.00
Ma		43.00	53.7	226.00
Pi		7.84	.8	113.88
Ro		4.05	17.7	328.81
To		4.73	3.1	485.40
Wa		51.61	71.8	169.77
Bu		3,861.00	--	19.76
Ph		84.00	--	43.67

1/

2/

Table D-11.--Pertinent data on reservoirs
Roanoke River Watershed

Reservoir name	Drainage area	Original storage capacity	Storage capacity per sq. mile drainage area	Estimated trap efficiency	Original cost of reservoir	Year completed	Cost of reservoir (1946 prices)	Age (1947)	Estimated annual rate of sediment production per 100 sq. mi. of drainage area	Annual rate of sediment accumulation	Total loss of storage to date	Cost per acre foot of storage
	sq.miles	acre ft.	acre ft.	percent	dollars		dollars	years	acre ft.	acre ft.	percent	dollars
Beaver Dam	1.7	1,381	812	98	187,714	1926	272,185	21	40	0.67	.01	197.09
Carvins Cove	18.0	19,948	1,108	98	2,056,770	1946	2,056,770	1	40	7.06	--	103.11
Falling Creek	1.5	261	174	95	60,397	1898	182,811	49	40	.57	1.1	700.43
Halifax	520.0	5,000	10	49	450,000	1920	855,000	27	50	127.40	68.8	171.00
Martinsville	374.0	1,200	3	23	113,000	1932	271,200	15	50	43.00	53.7	226.00
Pinnacles	20.0	8,035	402	98	610,000	1939	915,000	8	40	7.84	.8	113.88
Roxboro	7.5	531	71	87	97,000	1924	174,600	23	62	4.05	17.7	328.81
Towns	13.0 1/	1,380	106	91	481,155	1938	669,848	9	40	4.73	3.1	485.40
Walnut Cove	397.0	1,654	4	26	156,000	1924	280,800	23	50	51.61	71.8	169.77
Buggs Island 2/	7,800.0	2,921,000	374	99	57,730,000	--	57,730,000	--	50	3,861.00	--	19.76
Philpott 2/	212.0	201,500	950	99	8,800,000	--	8,800,000	--	40	84.00	--	43.67

1/ Exclusive of Pinnacles watershed.

2/ Project authorized and under construction.

Table D-12.--Benefits from reduction of reservoir sedimentation
Roanoke River Watershed

Reservoir Name	Original storage capacity	Reservoir cost (1946 prices)	Cost per acre foot storage	Annual loss of storage capacity		Annual reduction storage loss	Annual benefit
				Without program	With program		
	acre feet	dollars	dollars	acre feet	acre feet	acre feet	dollars
Beaver Dam	1,381	272,185	197	.67	.27	.40	79
Carvins Cove	19,948	2,056,770	103	7.06	2.82	4.24	437
Falling Creek	261	182,811	700	.57	.23	.34	238
Pinnacles	8,035	915,000	114	7.84	3.14	4.70	536
Roxboro	531	174,600	329	4.05	1.22	2.83	931
Townes	1,380	669,848	485	4.73	1.89	2.84	1,377
Buggs Island 1/	2,921,000	57,730,000	20	3,861.00	1,158,30	2,702.70	54,054
Philpott 1/	201,500	8,800,000	44	84.00	33.60	50.40	2,218

1/ Project authorized and under construction.

Table D-13

Physical land unit	Name	ual cost		Annual benefit with program
		it m	With program	
		s	Dollars	Dollars
Limestone Valley	Roanoke, Va.	0	18,615	3,285
	Salem, Va.	8	12,162	2,146
	Sub-total	8	30,777	5,431
Mountain-Foothills	Bedford, Va.	3	10,819	1,909
	Rocky Mount, Va.	0	6,375	1,125
	Sub-total	8	17,194	3,034
Piedmont Plateau	Fieldcrest Mills, Va. (1)	7	10,350	1,827
	Martinsville, Va.	7	14,464	2,553
	Fieldcrest Mills (	1	21,633	3,818
	Fieldcrest Mills (	0	32,946	5,814
	Leaksville, N. C.	9	10,650	1,879
	Riverside and Dan Cotton Mills, In	0	43,435	7,665
	Riverside and Dan Cotton Mills, In	0	20,774	3,666
	Riverside and Dan Cotton Mills, In	0	5,023	887
	South Boston, Va.	0	13,812	2,438
	Chatham, Va.	0	1,836	324
	Roxboro, N. C.	0	17,995	3,175
	Altavista, Va.	0	5,508	972
	Mayodan	2	8,867	1,565
	Roanoke Rapids, Va	5	29,261	5,164
	Weldon, N. C.	7	3,729	658
	Sub-total	3	240,283	42,405
	Grand total	4	288,254	50,870

1/ From figure D-2.

Table D-13.--Benefits from reduced cost of water treatment
Roanoke River Watershed

Physical land unit	Name	Source of supply: Stream	Source of supply: Type	Amount treated 1946	Cost of treatment	Annual cost: Without program	Annual cost: With program	Annual benefit with program
				MG	$ per MG	Dollars	Dollars	Dollars
Limestone Valley	Roanoke, Va.	Tributaries of Roanoke River	Retention reservoirs Springs and wells	730	30.0[1]	21,900	18,615	3,285
	Salem, Va.	Roanoke River	Run-of-river	365	39.2[1]	14,308	12,162	2,146
	Sub-total			1,095		36,208	30,777	5,431
Mountain-Foothills	Bedford, Va.	Stony Creek	Retention reservoirs	296	43.0[1]	12,728	10,819	1,909
	Rocky Mount, Va.	Pigg River	Run-of-river	60	125.0[1]	7,500	6,375	1,125
	Sub-total			356		20,228	17,194	3,034
Piedmont Plateau	Fieldcrest Mills, Fieldale, Va. (1)	Smith River	Run-of-river	263	46.3[1]	12,177	10,350	1,827
	Martinsville, Va.	Jones Creek	Run-of-river	374	45.5	17,017	14,464	2,553
	Fieldcrest Mills (2)	Smith River	Run-of-river	821	31.0	25,451	21,633	3,818
	Fieldcrest Mills (3)	Dan River	Run-of-river	456	85.0	38,760	32,946	5,814
	Leaksville, N. C.	Dan River	Run-of-river	158	79.3	12,529	10,650	1,879
	Riverside and Dan River Cotton Mills, Inc.	Dan River	Run-of-river	2,555	20.0	51,100	43,435	7,665
	Riverside and Dan River Cotton Mills, Inc.	Dan River	Run-of-rivor	1,220	20.0	24,440	20,774	3,666
	Riverside and Dan River Cotton Mills, Inc.	Dan River	Run-of-river	394	15.0	5,910	5,023	887
	South Boston, Va.	Dan River	Run-of-river	260	62.5	16,250	13,812	2,438
	Chatham, Va.	Cherrystone Creek	Run-of-river	60	36.0	2,160	1,836	324
	Roxboro, N. C.	Satterfield Creek	Retention reservoir	365	58.0	21,170	17,995	3,175
	Altavista, Va.	Roanoke River	Run-of-river	120	54.0	6,480	5,508	972
	Mayodan	Mayo River	Run-of-river	160	65.2[1]	10,432	8,867	1,565
	Roanoke Rapids, Va.	Roanoke River	Run-of-river	675	51.0	34,425	29,261	5,164
	Weldon, N. C.	Roanoke River	Run-of-river	65	67.5	4,387	3,729	658
	Sub-total			7,946		282,688	240,283	42,405
	Grand total			9,397		339,124	288,254	50,870

1/ From figure D-2.

Table D-14.--Total installation and maintenance costs of recommended program by groups of measures and allocations of costs (1946 prices)
Roanoke River Watershed

Measures	Unit	Total amount	Installation				Annual Operating and Maintenance Costs			
			Total cost	Federal	Non-Federal Public	Non-Federal Private	Total	Federal 5/	Non-Federal Public	Non-Federal Private
			Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Land treatment										
Open land										
1. Subwatershed waterways	Mile	420	504,000	378,000	--	126,000	42,000	--	--	42,000
2. Gully stabilization and sediment control	Mile	780	263,600	197,700	--	65,900	31,200	--	--	31,200
3. Erosion control along roads and railroads	Mile	4,799	492,700	246,400	221,000	25,300	98,500	--	88,300	10,200
4. Diversion channels	Mile	488	51,700	25,800	--	25,900	11,700	--	--	11,700
5. Terraces	Mile	46,180	2,447,500	1,223,800	--	1,223,700	554,200	--	--	554,200
6. Field border plantings	Acre	6,060	187,900	94,000	--	93,900	30,300	--	--	30,300
7. Farm waterways	Acre	22,880	1,075,400	537,700	--	537,700	160,200	--	--	160,200
Sub-total			5,022,800	2,703,400	221,000	2,098,400	928,100	--	88,300	839,800
Woodland										
8. Mountain watercourse control	Mile	38	300,000	240,000	--	60,000	10,000	10,000	--	--
9. Adequate fire control - private land	Acre	662,300	465,600	231,800	231,800	--	16,600	8,300	8,300	--
10. Woodland management: 1/										
Private land	Acre	2,187,500 ~~2,986,300~~	4,032,600 ~~5,023,000~~	2,301,800 ~~2,838,200~~	699,500 ~~932,700~~	1,031,300 ~~1,252,100~~	583,000	130,800	120,800	331,400
National forest land	Acre	22,300	19,300	19,300	--	--	--	--	--	--
Other federal land	Acre	69,800	55,100	55,100	--	--	4,200	4,200	--	--
Other public land	Acre	76,400	70,400	--	70,400	--	10,400	--	10,400	--
Total woodland management	Acre	~~3,154,800~~ 2,356,000	~~5,167,800~~ 4,177,400	~~2,912,600~~ 2,376,200	~~1,003,100~~ 769,900	~~1,252,100~~ 1,031,300	597,600	135,000	131,200	331,400
11. Tree planting:										
Private land	Acre	145,500 ~~161,100~~	2,636,800 ~~2,951,900~~	1,328,500 ~~1,476,100~~	525,100 ~~583,400~~	803,200 ~~892,400~~	--	--	--	--
National forest land	Acre	400	8,300	8,300	--	--	--	--	--	--
Other public land	Acre	1,800	37,200	--	37,200	--	--	--	--	--
Total tree planting	Acre	~~163,300~~ 147,200	~~2,997,400~~ 2,702,300	~~1,484,400~~ 1,336,800	~~620,600~~ 562,300	~~892,400~~ 803,200	--	--	--	--
12. Land acquisition:										
National forest land	Acre	10,000	68,000	68,000	--	--	--	--	--	--
Other public land	Acre	60,000	408,000	--	408,000	--	--	--	--	--
Total land acquisition	Acre	70,000	476,000	68,000	408,000	--	--	--	--	--
Sub-total	Acre	3,154,800	9,404,800	4,936,800 1/	2,263,500 2/	2,204,500	624,200	153,300	139,500	331,400
Other measures										
13. Tributary channel improvement and streambank stabilization	Mile	2,782	2,629,600	2,103,600	--	526,000	154,100	--	--	154,100
Facilitating services										
14. Technical services 3/			2,385,800	2,385,800	--	--	--	--	--	--
15. Educational assistance			400,000	200,000	200,000	--	--	--	--	--
Sub-total			2,785,800	2,585,800	200,000					
Total Cost			19,843,000	12,329,600 4/	2,684,500	4,828,900	1,706,400	153,300	227,800	1,325,300

1/ Includes $1,198,800 for technical services
2/ Includes $1,179,000 for technical services.
3/ Includes $2,285,800 for investigations, designs, planning, and integrating measures, and $100,000 for maintenance required during the period of installation.
4/ An estimated $295,000 of this amount is for administration of direct aids.
5/ Technical services.

Table D-15.--Summary and distribution of costs of recommended program
Roanoke River Watershed

Land Treatment	Installation			Annual operation and maintenance		
		Non-Federal			Non-Federal	
	Federal	Public	Private	Federal	Public	Private
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Open land	2,703,400	221,000	2,098,400	--	88,300	4,859,200 1/
Woodland	4,936,800	2,263,500	2,204,500	153,300	139,500	331,400
Facilitating services	1,663,700	200,000	--	--	--	--
Total	9,303,900	2,684,500	4,302,900	153,300	227,800	5,190,600
Annual equivalent of installation costs	232,600	67,100	172,100	--	--	--
Tributary channel improvement and stream bank stabilization	2,103,600	--	526,000	--	--	154,100
Facilitating services	922,100	--	--	--	--	--
Total	3,025,700	--	526,000	--	--	--
Annual equivalent of installation costs	75,600	--	21,000	--	--	--
Total annual costs	308,200	67,100	193,100	153,300	227,800	5,344,700

1/ This item includes $839,800 annual maintenance of measures and $4,019,400 added cost of farm operations.

Table D-16.--Channel improvement and stream bank stabilization summary of amounts, costs, and allocation of costs
Roanoke River Watershed

Item	Unit	Amount	Installation cost			Annual maintenance
			Total	Federal	Private	Private
			Dollars	Dollars	Dollars	Dollars
Channel improvement (brushing and snagging)	Mile	2,782	1,876,300	1,501,000	375,300	139,100
Channel dredging and realignment	Mile	281 1/	753,300	602,600	150,700	15,000
Total	Mile	2,782 1/	2,629,600	2,103,600	526,000	154,100

1/ The 281 miles of channel dredging and realignment represents miles receiving dual treatment and does not add to total miles treated.

Table D-17.--Cost of erosion control along roads and railroads
Roanoke River Watershed

Physical land unit	Roads					Railroads				
	Miles of treatment	Installation			Annual maintenance	Miles of treatment	Installation			Annual maintenance
		Total	Federal	Non-Federal Public	Non-Federal Public		Total	Federal	Private	Private
		Dollars	Dollars	Dollars	Dollars		Dollars	Dollars	Dollars	Dollars
Limestone Valley	156	16,000	8,000	8,000	3,200	45	4,600	2,300	2,300	930
Mountain-Foothills	1,088	110,900	55,400	55,500	22,200	86	9,000	4,600	4,400	1,800
Piedmont Plateau	3,063	314,800	157,300	157,500	62,900	361	37,400	18,800	18,600	7,470
Total	4,307	441,700	220,700	221,000	88,300	492	51,000	25,700	25,300	10,200

Table D-18.--Increased production on bottomlands resulting from channel improvement Roanoke River Watershed

Physical land unit	Acres affected	Estimated increase in net returns per acre	Total increase or benefit
		Dollars	Dollars
Mountain-Foothills	6,200	4	24,800
Piedmont Plateau	51,000	3	153,000
Total	57,200		177,800

Table D-19.--Current and expected values of a cubic foot of wood

Forest product	Current stumpage value 1/	Current value per cubic foot	Current annual drain 2/	Expected annual drain 3/	Current weighted value	Weighted expected value
	Dollars	Dollars	Percent	Percent	Dollars	Dollars
Lumber	18.00	0.0900	53.0	40	0.0477	0.0360
Fuel wood	1.00	.0143	22.0	20	.0031	.0029
Pulpwood	3.00	.0375	13.4	20	.0050	.0075
Veneer	25.00	.1634	1.4	5	.0023	.0082
Cooperage	7.00	.0823	2.0	4	.0016	.0033
Piling	25.00	.1634	0.7	5	.0011	.0082
Miscellaneous	16.00	.0875	7.5	6	.0066	.0053
	Average value per cubic foot ——				.0674	.0714

1/ Source - Norris-Doxey Reports 1946-47. Forest Utilization Service, Southeastern Forest Experiment Station, Region 8, U. S. Forest Service.
2/ Source - Forest survey data.
3/ Source - Reappraisal Report No. 2.

Table D-20.--Factors for converting forest products to cubic feet

Forest Product	Common unit of measure	Cubic foot equivalent
Lumber	1,000 bd. ft.	200
Fuel wood	cord	70
Pulpwood	cord	80
Veneer logs	1,000 bd. ft.	153
Cooperage	cord	85
Piling	1,000 bd. ft.	180
Miscellaneous	1,000 bd. ft.	180

Source - Forest Utilization Service, Northeastern Forest Experiment Station.

Table D-21.--Cost of forest planting on private lands for recommended program
Roanoke River Watershed

Physical land unit	Area to be planted 1/	Cost			
		Federal	Other public	Private	Total
	Acres	Dollars	Dollars	Dollars	Dollars
Limestone Valley	4,200	41,400	14,000	27,100	82,500
Mountain-Foothills	21,700	224,500	78,900	145,600	449,000
Piedmont Plateau	135,200	1,210,200	490,500	719,700	2,420,400
Total	161,100	1,476,100	583,400	892,400	2,951,900

1/ Includes full planting by hand and by machine and spot planting.

)PS PER ACRE

Crop	)nt)ent rease	Dan River Piedmont Present	 Future	 Percent Increase
Corn	50	22	33	50
Bright Tobacco	20	1,032	1,238	20
Dark Tobacco	30	989	1,286	30
Cotton, Lint	30	--	--	--
Cotton, Seed	30	--	--	--
Peanuts, Nuts	--	--	--	--
Peanuts, Hay	--	--	--	--
Alfalfa Hay	50	1.8	3	65
All Other Hay	100	1	2	100
Soybeans	--	--	--	--
Wheat	40	16	24	50
Oats	--	--	--	--
Truck, vegetables and small fruits	30	125	169	35
Fruit and nut orchards and vineyards	30	180	252	40
Pasture	100	1.7	3.4	100

Table L-22.--EFFECTS OF FARM LAND TREATMENT MEASURES ON PRODUCTION OF MAJOR CROPS PER ACRE
ROANOKE RIVER WATERSHED

Crop	Unit	Limestone Valley			Mountain-Foothills			Roanoke River Piedmont			Dan River Piedmont		
		Present	Future	Percent Increase	Present	Future	Percent Increase	Present	Future	Percent Increase	Present	Future	Percent Increase
Corn	Bu.	31	40	30	27	38	40	22	33	50	22	33	50
Bright Tobacco	Lb.	--	--	--	941	1,129	20	1,038	1,246	20	1,032	1,238	20
Dark Tobacco	Lb.	--	--	--	--	--	--	995	1,294	30	989	1,286	30
Cotton, Lint	Lb.	--	--	--	--	--	--	451	586	30	--	--	--
Cotton, Seed	Lb.	--	--	--	--	--	--	736	956	30	--	--	--
Peanuts, Nuts	Lb.	--	--	--	--	--	--	--	--	--	--	--	--
Peanuts, Hay	Ton	--	--	--	--	--	--	--	--	--	--	--	--
Alfalfa Hay	Ton	1.9	3	60	2.1	3	45	2	3	50	1.8	3	65
All Other Hay	Ton	1.2	2.2	85	1	1.6	60	1	2	100	1	2	100
Soybeans	Bu.	8.8	15	70	--	--	--	--	--	--	--	--	--
Wheat	Bu.	20	30	50	16	22	35	17	24	40	16	24	50
Oats	Bu.	27	40	50	21	36	50	--	--	--	--	--	--
Truck, vegetables and small fruits	Dol.	122	171	40	107	160	50	130	169	30	125	169	35
Fruit and nut orchards and vineyards	Dol.	235	282	20	193	270	40	195	254	30	180	252	40
Pasture	A.U.Mos.	2	4	100	1.7	3.4	100	1.7	3.4	100	1.7	3.4	100

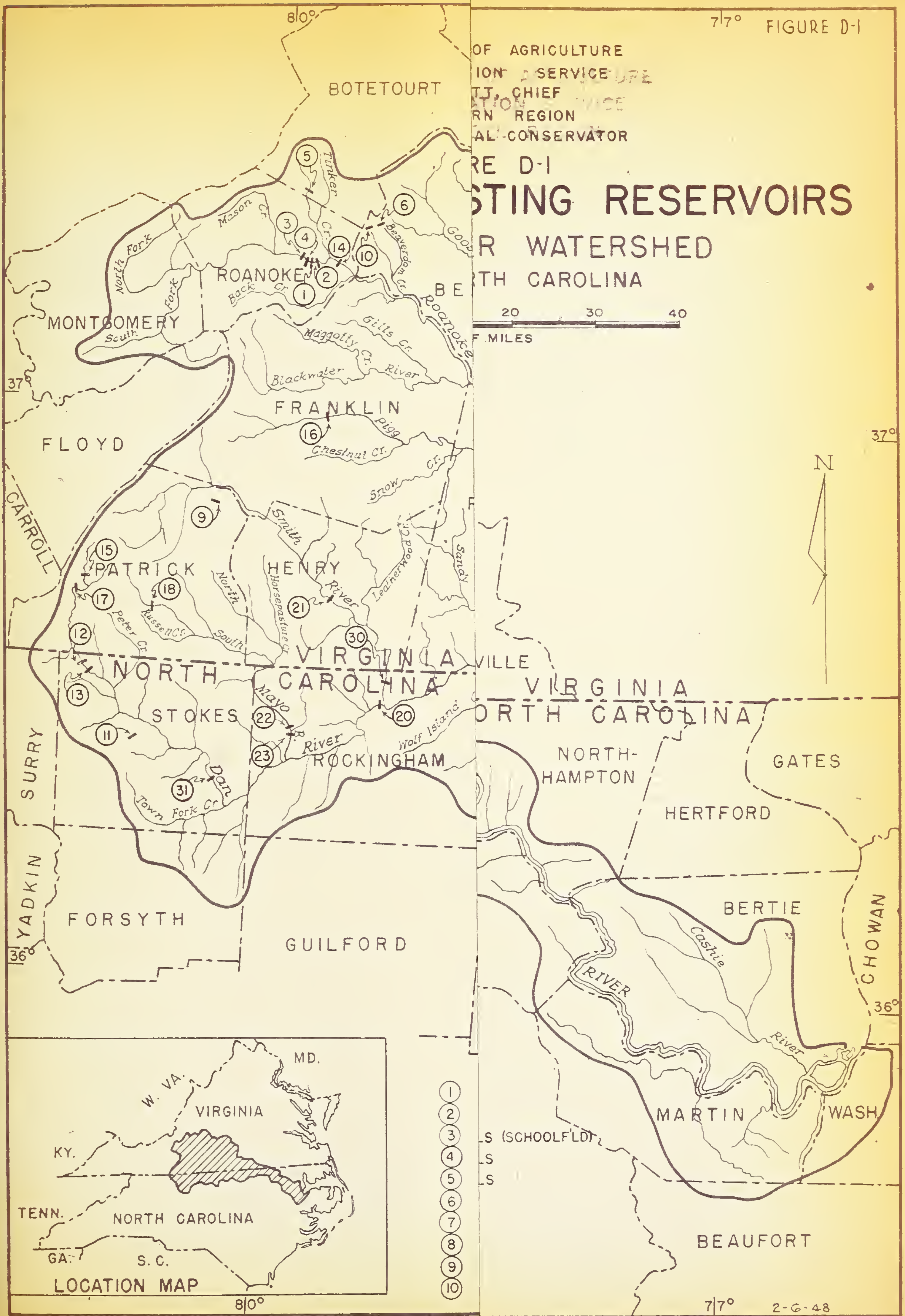
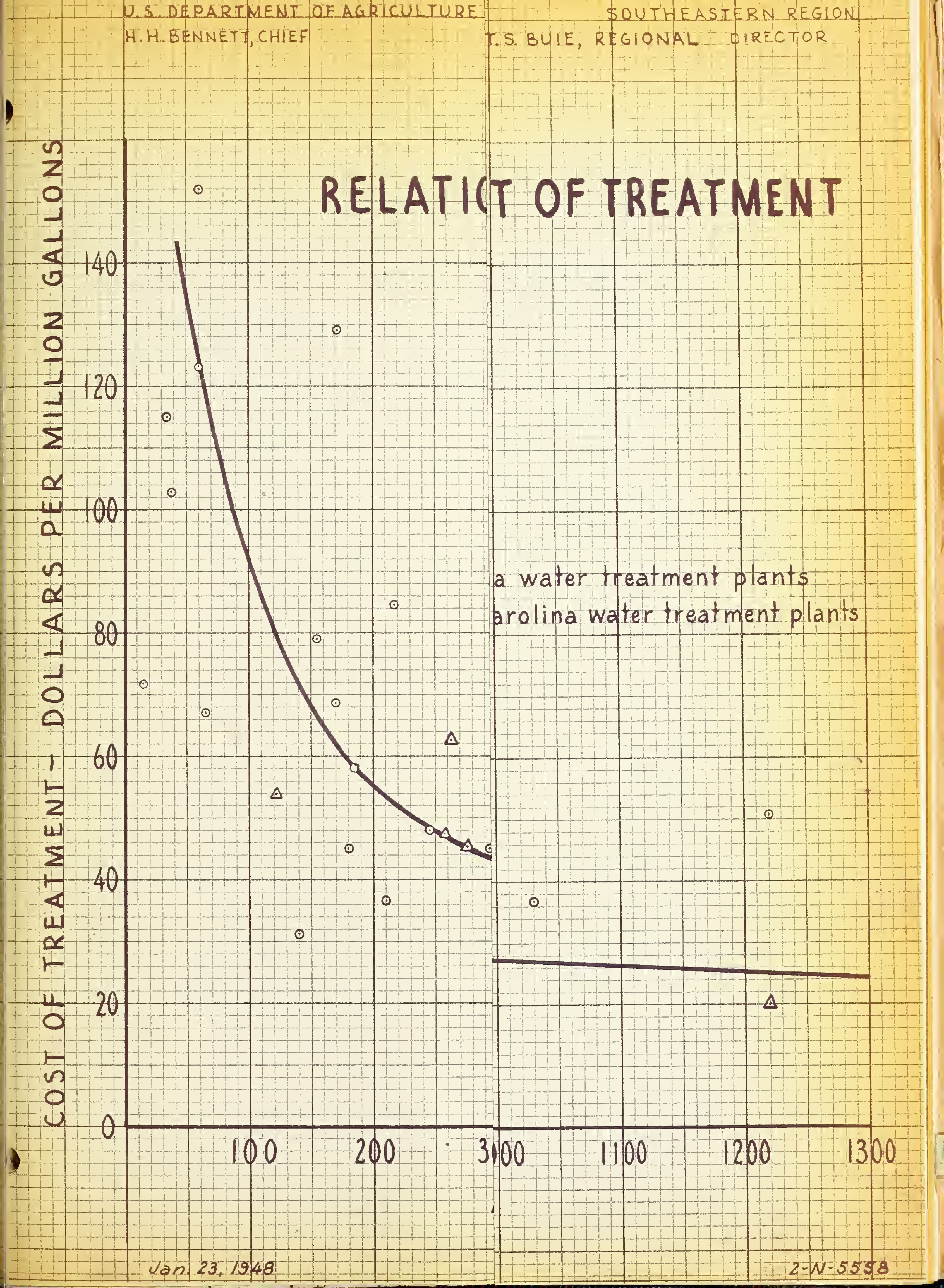


FIGURE D-1
OF AGRICULTURE
ION SERVICE
TT, CHIEF
RN REGION
AL CONSERVATOR
RE D-1
STING RESERVOIRS
R WATERSHED
RTH CAROLINA
20 30 40
F MILES
80°
77°
37°
36°
N
BOTETOURT
MONTGOMERY
ROANOKE
BE
FRANKLIN
FLOYD
CARROLL
PATRICK
HENRY
VIRGINIA
NORTH CAROLINA
STOKES
ROCKINGHAM
SURRY
YADKIN
FORSYTH
GUILFORD
VILLE
VIRGINIA
ORTH CAROLINA
NORTH-HAMPTON
GATES
HERTFORD
BERTIE
CHOWAN
MARTIN
WASH.
BEAUFORT
Tinker Cr.
Mason Cr.
North Fork
Fork
South
Back Cr.
Beaverdam Cr.
Goose
Roanoke
Gills Cr.
Maggotty Cr.
Blackwater River
Pigg
Chestnut Cr.
Snow Cr.
Smith
River
Leatherwood Cr.
Sandy
North
Horsepasture Cr.
Russell Cr.
South
Peter Cr.
Mayo R.
River
Dan
Town Fork Cr.
Wolf Island
Cashie
RIVER
River
1 2 3 4 5 6 9 10 11 12 13 14 15 16 17 18 20 21 22 23 30 31
LS (SCHOOLF'LD)
LS
LS
1 2 3 4 5 6 7 8 9 10
MD.
W. VA.
VIRGINIA
KY.
TENN.
NORTH CAROLINA
GA.
S. C.
LOCATION MAP
2-6-48

2-N-5597-1

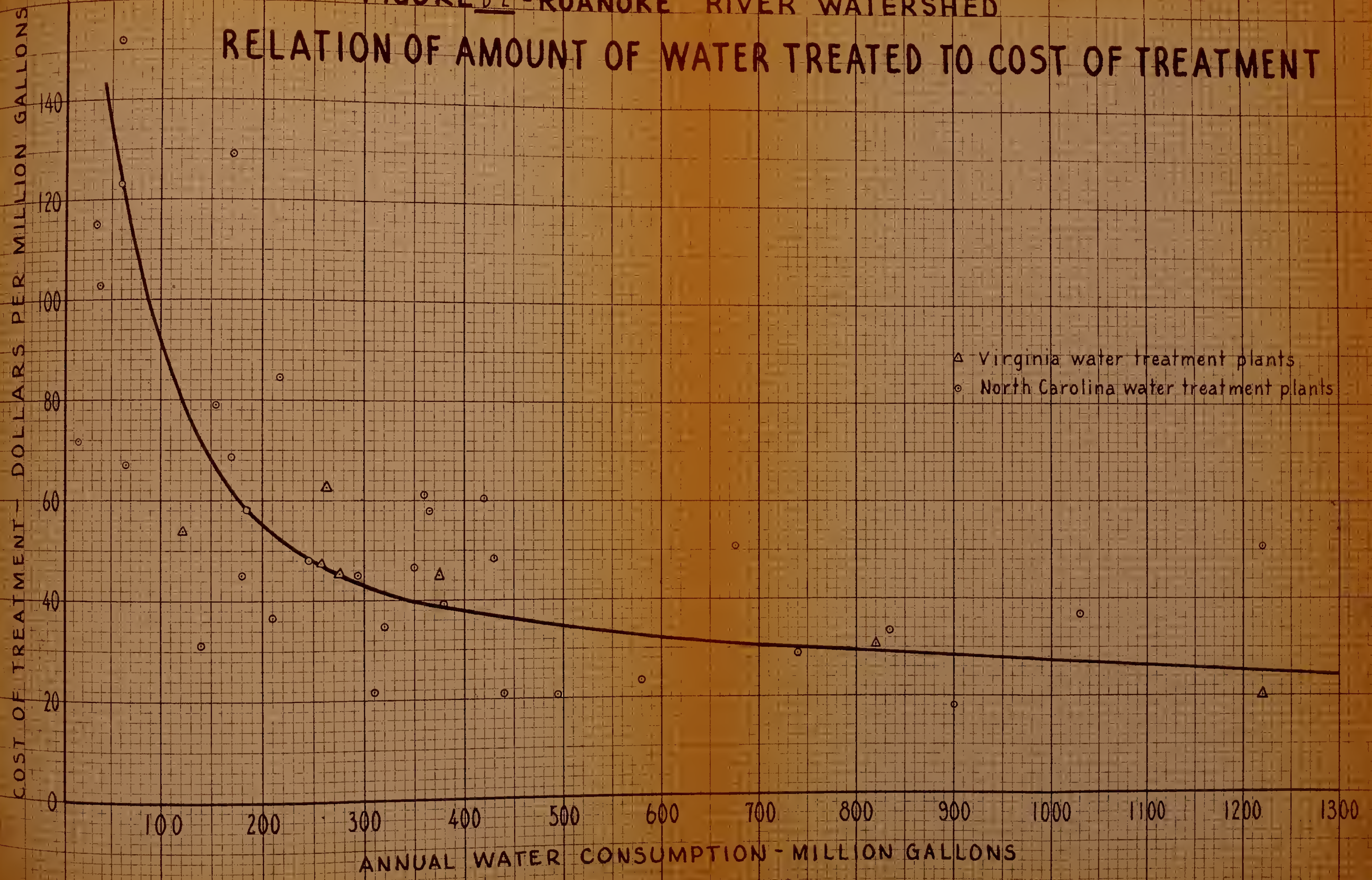
FIGURE D-1
LOCATION OF EXISTING RESERVOIRS



U.S. DEPARTMENT OF AGRICULTURE
H.H. BENNETT, CHIEF
SOUTHEASTERN REGION
T.S. BUIE, REGIONAL DIRECTOR
RELATIC T OF TREATMENT
a water treatment plants
arolina water treatment plants
COST OF TREATMENT – DOLLARS PER MILLION GALLONS
0
20
40
60
80
100
120
140
100
200
3 00
1100
1200
1300
Jan. 23, 1948
2-N-5558

FIGURE D-2 - ROANOKE RIVER WATERSHED

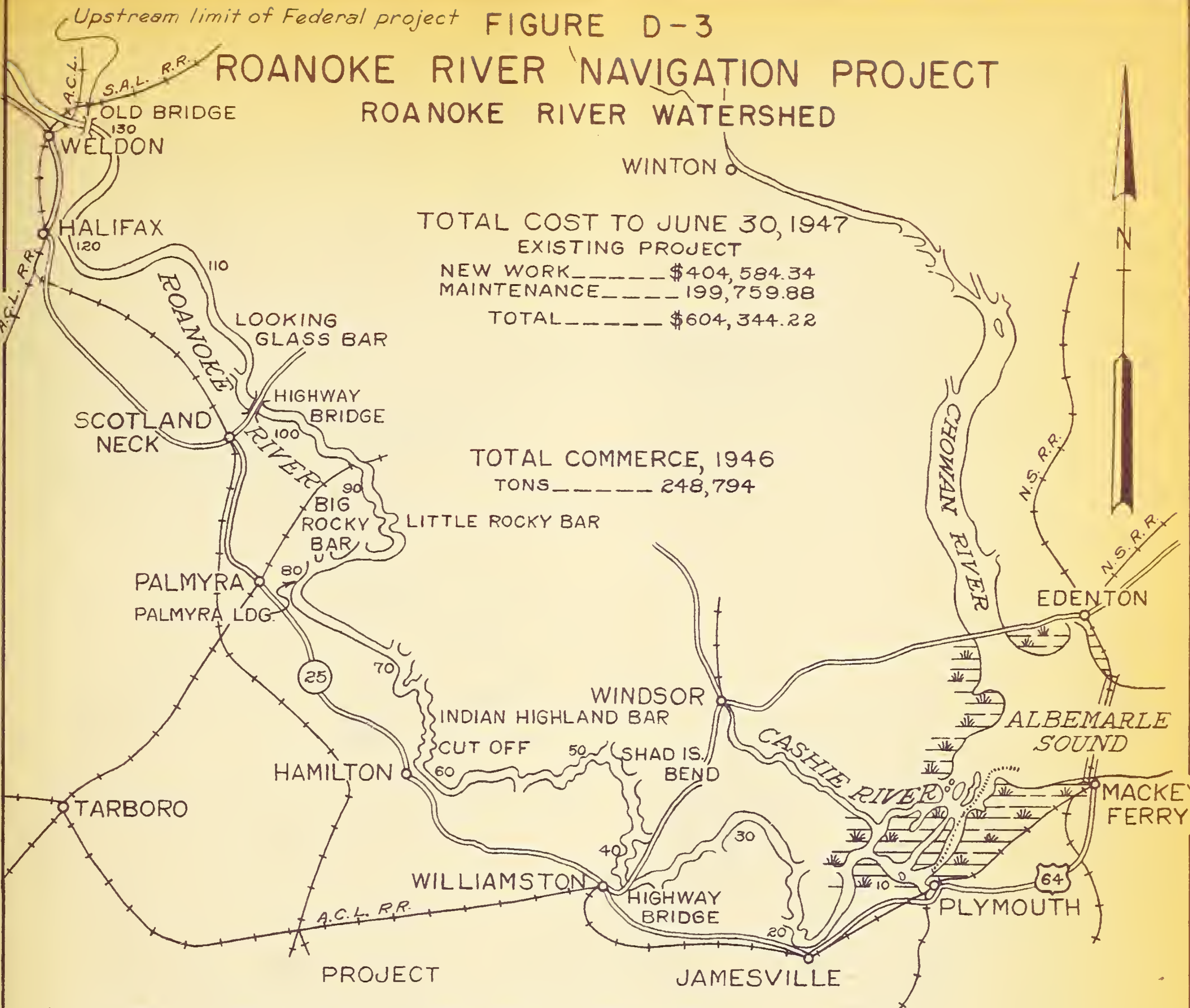
RELATION OF AMOUNT OF WATER TREATED TO COST OF TREATMENT



Jan. 23, 1948

2-N-5558

FIGURE D-3
ROANOKE RIVER NAVIGATION PROJECT
ROANOKE RIVER WATERSHED



PROVIDES FOR DREDGING A CHANNEL 12 FEET DEEP AND 150 FEET WIDE FROM THE 12-FOOT CONTOUR IN ALBEMARLE SOUND INTO ROANOKE RIVER AND THENCE UPSTREAM TO A POINT ABOUT 1 MILE ABOVE THE TOWN OF PLYMOUTH, N.C., 10 MILES; THENCE A CHANNEL 10 FEET DEEP AND 100 FEET WIDE TO HAMILTON, 53 MILES; THENCE A CHANNEL 8 FEET DEEP AND 80 FEET WIDE TO PALMYRA LANDING, 18 MILES, WITH A CUT-OFF CHANNEL OF LIKE DIMENSIONS ABOUT 2 MILES ABOVE HAMILTON; AND THENCE A CHANNEL 5 FEET DEEP AND 50 FEET WIDE TO WELDON, N.C., 50 MILES, BY DREDGING, SNAGGING, AND REGULATION. THE STREAM IS NON-TIDAL BUT SUBJECT TO FRESHETS.
THE PROJECT IS COMPLETED TO PALMYRA LANDING. THE PERCENTAGE OF COMPLETION ABOVE PALMYRA IS UNCERTAIN AS IT IS IMPRACTICABLE TO OBTAIN AND MAINTAIN THE PROJECT BY DREDGING, SNAGGING, AND REGULATION.
THE CONTROLLING DEPTHS ARE 9.9 FEET TO ONE MILE ABOVE PLYMOUTH; 7.4 FEET TO HAMILTON; 3.1 FEET TO PALMYRA; 1 FOOT TO WELDON.

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SOUTHEASTERN REGION
T. S. BUIE, REGIONAL DIRECTOR

ROANOKE RIVER
NORTH CAROLINA

SCALE OF MILES
10 0 10

WAR DEPARTMENT, CORPS OF ENGINEERS
WILMINGTON, N.C.

Traced by
U.S.D.A.-S.C.S.
1-26-48

2-L-5548-2

FIGURE D-4
CASHIE RIVER NAVIGATION PROJECT
ROANOKE RIVER WATERSHED

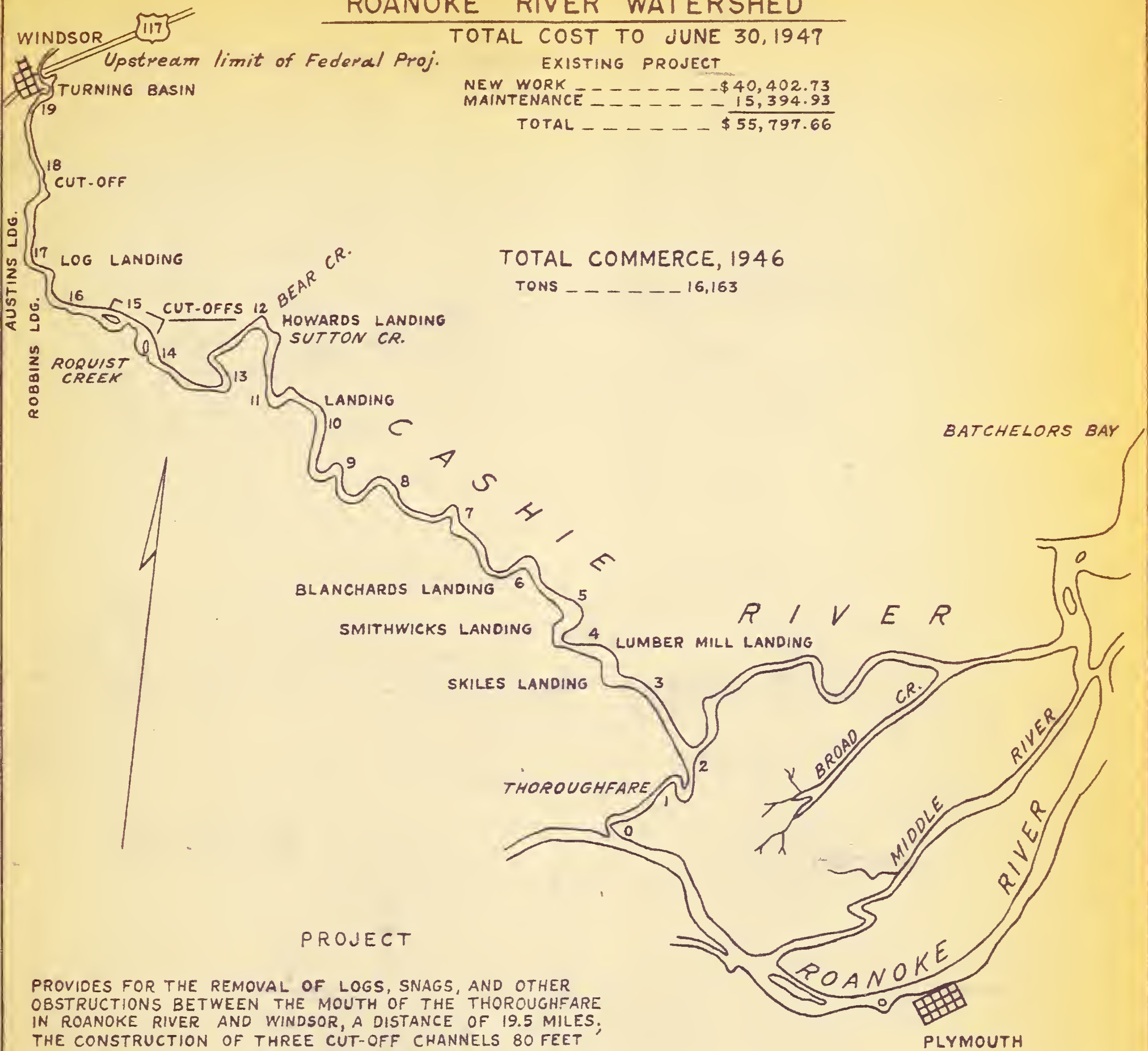
TOTAL COST TO JUNE 30, 1947

EXISTING PROJECT

NEW WORK	$40,402.73
MAINTENANCE	15,394.93
TOTAL	$55,797.66

TOTAL COMMERCE, 1946

TONS ________ 16,163



PROJECT

PROVIDES FOR THE REMOVAL OF LOGS, SNAGS, AND OTHER OBSTRUCTIONS BETWEEN THE MOUTH OF THE THOROUGHFARE IN ROANOKE RIVER AND WINDSOR, A DISTANCE OF 19.5 MILES, THE CONSTRUCTION OF THREE CUT-OFF CHANNELS 80 FEET WIDE THROUGH SHARP BENDS AT POINTS 1, 4, AND 5 MILES BELOW WINDSOR, AND A TURNING BASIN ABOUT 1.1 ACRES IN AREA AT WINDSOR, ALL TO A DEPTH OF 10 FEET.
THE PROJECT HAS BEEN COMPLETED.
THE RIVER IS NOT SUBJECT TO FLOODS OR FRESHETS, BUT ITS WATER SURFACE RISES AND FALLS AS WINDS RAISE OR LOWER THE WATER LEVEL IN ALBEMARLE SOUND. THE MAXIMUM FLUCTUATION OF THE WATER SURFACE IS ABOUT 4 OR 5 FEET.
THE CONTROLLING DEPTH IS 10 FEET.

U.S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, CHIEF
SOUTHEASTERN REGION
T. S. BUIE, REGIONAL DIRECTOR

CASHIE RIVER
NORTH CAROLINA

SCALE OF MILES

0 1 2 3 4

WAR DEPARTMENT, CORPS OF ENGINEERS
WILMINGTON, N.C.

Traced by
U.S.D.A. - S.C.S.
1-26-48

2-L-5548-1

APPENDIX E

PLAN OF IMPROVEMENT

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Tables

Figures

INTRODUCTION

The recommended watershed treatment program for the Roanoke River drainage basin in Virginia and North Carolina has been developed with the primary objective of alleviating flood water and sediment damages.

The total area of the drainage basin is approximately 6,131,200 acres (9,580 square miles), of which 3,942,400 acres (6,160 square miles) are in Virginia and 2,188,800 acres (3,420 square miles) are in North Carolina.

Of the total area, about 71 percent or 4,375,700 acres, is land in farms and about 29 percent or 1,755,500 acres is land not in farms. Most of the non-farm lands, except 663,612 acres of miscellaneous lands, portions of which are located on farms, are included in non-farm woodland and treated as such in this report.

In the development of the recommended program special consideration has been given to thos measures which will result in maximum flood control and water conservation benefits. Because of the interrelation between such measures and sound land use practices, it is essential that a complete system of soil and water conservation be developed as an integral part of the recommended program if maximum benefits are to be realized.

For evaluation purposes all measures included in the watershed treatment program have been grouped as follows:

Group 1 - All land treatment measures and other measures closely associated with land treatment.

Group 2 - Measures not included in Group 1 but supplemental to land treatment measures.

Measures included in Group 1 have further been subdivided into the two groups:

A. Land treatment measures that will be installed under the "going" programs during installation period.

B. All remaining land treatment measures and additional measures essential to the application and proper functioning of the land treatment measures.

Procedure Used in Developing Recommended Program

Present land use and physical land conditions indicated by capability classes were used as basic material in developing data on the present condition of the watershed. Recommendations for land treatment were developed to show the needs for treatment w ithin the watershed. These recommendations are based on experience of the Soil Conservation

Service, Forest Service, and other local agricultural workers, and that of local soil conservation district supervisors. Accomplishments on farms through June 1947 were considered in the estimated needs as to kinds and amounts of measures.

The entire watershed area is in active soil conservation districts. Conferences on program development were held with supervisors of these districts, technicians, and representatives of other agencies. At each of these conferences data were presented indicating present land use as revealed by the 1945 census and other acceptable sources of information. Tabulations were also shown indicating the acreage of land capability classes in each land use as obtained from sample soil conservation surveys. Using these data as a basis, also taking into consideration local agricultural trends, including availability of farm labor and present economic conditions, the supervisors recommended land use changes as well as the conservation practices needed for a complete watershed treatment program in their respective districts. Present and proposed uses, together with net changes by physical land units, are shown in table E-1.

These proposed land use changes are based on recommendations of the governing bodies of local soil conservation districts, but adjusted to and summarized by major physical land units. The physical land units are shown in figure E-1. The significant changes are: decreased rotated crop land, 92,147 acres; increased pasture, 117,514 acres; increased woodland, 181,020 acres; increased perennial vegetation, 146,241 acres; increased areas for wildlife, 15,087 acres; and the application of beneficial measures to 369,346 acres of idle land.

An estimate of watershed needs for flood control by measures, the reported accomplishment of "going" programs, and the recommended program are shown in table E-2.

In order to determine the annual rate of accomplishment of the "going" programs for the needed measures, records and reports of the various agencies concerned were analyzed and consolidated.

Fiscal year 1949 was used as the basis for estimating the annual rate of accomplishments on farms cooperating with soil conservation districts, and in estimating costs of technical assistance. Years considered most representative as to accomplishment rates of the Production and Marketing Administration were used by that agency in each state.

GROUP 1 MEASURES - LAND TREATMENT

Open Land

The proposed measures and practices for both flood control and conservation of watershed lands will conserve soil and water, improve infiltration, reduce runoff, and increase soil fertility. The recommended measures for open land are: (1) subwatershed waterways,

(2) gully stabilization and sediment control, (3) erosion control along railroads and roadways, (4) diversion channels, (5) terraces, (6) field border plantings, (7) farm waterways, (8) other farm and water conservation practices and measures, including technical and educational assistance and direct aids.

There are approximately 247,300 acres of crop, idle, and pasture lands in land capability class 7 (table A-1, Appendix A). Since these generally severely eroded areas are an important source of silt and accelerated runoff which increase flood hazards and damages, it is desirable that they be planted to perennials and/or trees.

In addition to the measures listed above, the recommendations include crop rotations (including both summer and winter cover crops), strip cropping, contour cultivation, fertilizing and liming. These pertinent land use changes and essential conservation measures serve a dual purpose in the recommended program. First, they reduce runoff and sedimentation from critical silt-source areas which result in distinct public benefits. Second, they conserve soil and water and improve the fertility, with accompanying increased revenue to landowners, which results in private benefits.

The recommended program imposes no major change in the acreage of cash crops. Principal cash crops will continue to be cotton, tobacco, and peanuts, except in the mountains where fruits and vegetables will predominate.

Subwatershed Waterways

The waterways on individual farms discharge storm runoff into secondary channels, which in turn flow through other farms and finally discharge into the tributary streams. This concentrated volume of uncontrolled runoff produces excessive scour in the secondary channels, which will seriously damage the bottom lands by deposition of harmful sediment. It is therefore important that adequate water-disposal systems be planned, established and maintained as group enterprises.

When the water disposal system of two or more individual farms discharges into a common outlet, it is necessary to provide adequate channel capacity, as well as apply measures which will prevent both excessive scour and the formation of gullies. In some cases this difficulty can be alleviated only by providing channel outlets entirely across the flood plains to the tributary stream outlets. Disposal of water from hill lands without flood damage to fertile bottom lands is dependent on adequate channel outlets.

In some cases, topography will permit the establishment of perennial vegetative outlets for group water disposal systems. Where secondary channels exist, brushing and some grading may be necessary to prevent meandering and impediment of stream flow. In some instances, structures may be necessary where large quantities of runoff or eroding soils occur.

In the design of water disposal systems for subwatersheds it is sometimes necessary to provide for a small amount of flood water storage in some of the structures. These small detention type flood water storage measures are recommended for use in water disposal systems as stabilizing measures in headwater areas. They will consist of small earth filled dams with an outlet to release water at a fixed and safe rate, and with auxiliary spillways adapted to site conditions. Since these installations will be small, their effectiveness will be most beneficial in reducing the installation cost of control measures immediately below the site. They will also produce additional benefits by furnishing some protection to flood plain lands and improvements.

Approximately 420 miles of subwatershed waterways will require treatment.

Gully Stabilization and Sediment Control

Gullies are one of the principal sources of sediment. The effectiveness of the recommended program in reducing sedimentation damages depends to a large extent on the control of gully erosion.

It is estimated that there are approximately 780 miles of major gullies which will require treatment. The treatment of gullies excludes occasional gullies which will be stabilized under normal farm conservation operations.

Gully treatment will consist of vegetative stabilization and supporting structural measures as required. Mulching, small check dams, and structural measures will facilitate the establishment of trees, kudzu, sericea, grass, shrubs, and other perennials. Temporary dikes and diversion ditches will be constructed to intercept and divert runoff from overlying areas into stabilized waterways where practicable. Fence construction and vegetative barriers will be used where necessary for protection of such areas from grazing.

Sediment can be controlled by measures that spread and reduce the velocity of flood flows. Temporary earth dams may be used at the mouth of large gullies. Vegetative barriers are most effective. Plants that are close growing, deep rooted, with low dense foliage which is not readily eaten by livestock, are recommended. Usually bottom lands of low value or lands already damaged by deposition will be used for desilting areas.

Erosion Control Along Roads and Railroads

A reconnaissance survey was made to ascertain the present condition of road systems within the Roanoke watershed and to estimate types and amounts of erosion control measures necessary to stabilize cut and fill slopes.

It was found that the system of highways and roads within the several sample tributary areas is comparable to the system of roads throughout the physical land units which they represent. This is true for the types of roads, as well as the need for the application of measures to stabilize cut and fill slopes, gullies, intercepting and outfall ditches.

Within the sample tributary areas, as throughout the Roanoke drainage basin, the entire road system lends itself to classification by three types of roads: principal highways (hard surface), improved roads (soil type and surface treated), and unimproved roads.

It was found that the principal highways would require the application of the greatest amounts of stabilization measures. This is a reflection of larger cut and fill areas per mile of highway due to more exacting requirements with respect to grade and alignment.

The improved roads will require smaller amounts of stabilization measures than the principal highways, but larger amounts than the unimproved roads. Existing gullies adjacent to roads will also require vegetative stabilization measures.

Highways and roads in the Dan River portion of the Piedmont Plateau will require the application of stabilization measures of highest intensity. Roads in the Roanoke River portion of the Piedmont Plateau, the Mountain-Foothills and the Limestone Valley areas will require the application of stabilization measures in decreasing amounts in the order named.

Recommended Stabilization Measures - The recommended measures for roadside erosion control consist of stabilizing structures and vegetative plantings as may be required on all highways and public roads within the watershed.

The measures applicable to roadways will generally consist of seedbed preparation, including fertilization, seeding, or planting of vegetative cover, as well as mulching steep slopes with grass and weeds which may be mowed from the rights-of-way. Shrubs, trees, or other suitable vegetation will be planted in appropriate locations along high velocity outfall ditches and other silt source areas. Structures will be used only where large quantities of concentrated runoff or erodible soils make vegetative measures inadequate.

Vine type perennial vegetation will be more effective and economical on the deeper and steeper cut slopes and ditch sections. Perennials and reseeding annual types of vegetation will be more suitable for treating the flatter slopes where conditions are more favorable for their growth.

Stabilization of road cut and fill slopes and drainageways will effect a major reduction in the volume of sand and silt transported from these areas. This will greatly reduce the volume of such material deposited in road ditches and drainageways, or on lower lying agricultural land and in the streams. The cost of maintenance of road rights-of-way and damages to adjacent farm lands will be reduced to a minimum as a result of stabilization.

It is estimated that approximately 4,307 miles of roads need treatment.

Erosion Control along Railroads - Erosion control along railroad rights-of-way differs from that of highways in that the fill slopes along railways are usually protected with adequate vegetation in order to maintain the roadbed. However, the steep unprotected cut slopes contribute large quantities of silt and it is these areas on which the major portion of vegetative planting is necessary along railroads. It is estimated that 492 miles of railroad cut slopes will need vegetative treatment.

Diversion Channels and Terraces

Diversion channels will be installed on slopes and at toe-slopes too steep for terraces where orderly discharge of surface runoff is necessary for the protection of lands lying immediately below them. Terraces will be installed to manage the runoff from sloping cultivated lands to reduce soil erosion and sediment damage. Approximately 488 miles of diversion channels and 46,180 miles of terraces are recommended.

Field Border Plantings

Small, irregular, and inaccessible areas, as well as narrow strips of land along field borders, often left idle, are sources of serious erosion and present annoying runoff problems. It is proposed that this condition be corrected by planting approximately 6,060 acres of such areas to adapted plants that will control erosion and produce food and cover for wildlife.

Farm Waterways

Farm waterways will consist of both natural and artificial water courses to provide safe disposal of excess water from farms. Farm waterways will, in most cases, be vegetated and will include such measures as broad meadow strips, constructed channels, and vegetated terrace outlets. The natural topography of adjacent farms will determine the planning and installation of water disposal systems in order that the water disposal systems of contiguous farms may operate as a unit. Waterways will usually extend from the top of terraced slopes to suitable outlets. In some cases it will be necessary for waterways to cross flood plain land to reach suitable outlets. The proper disposal of excess water from farm land into adequate outlets will reduce sediment damage to bottom lands and minimize damage to crops on these areas. Supporting structures will be installed to implement vegetative control where necessary. It is estimated that 22,880 acres of farm waterways will be needed.

Woodland

1. Mountain Watercourse Control.--The continued widespread misuse of the forested mountain portions of the Roanoke River watershed over the past 150 years by uncontrolled burning, over-grazing, destructive logging, land clearing and abandonment has seriously upset stream regimen. The cumulative effects of such past practices are reflected in such highly unstable conditions of mountain watercourses as bank undercutting, channel scour, debris avalanches and the gullying of minor slope drainage. In some cases well-defined channel courses in the headwater valleys have been destroyed, so that flood waters spread over the valley floors causing bottomland scour and bank cutting, and periodically adding additional debris loads to the channels below, following heavy winter or spring rains or intense summer storms.

Although watercourse stability will gradually be restored for the most part by the forest land treatment measures recommended in this report, the disturbances have proceeded so far within certain localized areas that recovery cannot be expected without the application of special supplemental stabilizing measures on the more seriously gullied slopes and in and along the minor watercourses most seriously affected.

This type of work corresponds closely with the gully stabilization and sediment control measures recommended as part of the treatment for the crop and pasture areas at lower elevations in the Piedmont portion of the watershed. The major differences are that the mountain slopes and drainage courses are steeper, precipitation is higher and more intense, and the land is predominantly in forest cover.

Purposes of the supplemental headwater treatments are to reduce debris movement, channel scour and bank undermining and to retard heavy surface runoff and concentrated flood flows. Treatments will consist primarily of (a) small rock and brush check dams at carefully selected sites in the channels of actively eroding drainage to help prevent further gullying and to hold the soil in place

pending the establishment of deep-rooted vegetation; (b) installation of lead-off or diversion ditches to take water from the surface of unstable earth slides or gullies and spread it harmlessly over the adjacent undisturbed soil and humus areas; (c) planting of black locust, lespedeza, or other suitable deep-rooted species at the heads of actively eroding slides to speed up their recovery.

The work will be confined to the most critical locations within the forested mountainous area of the watershed and will be tied in closely with the other forest land treatment measures so as to attain maximum benefits. It will be applied only where adequate participation in the total program for the subwatersheds concerned can reasonably be assured. In less critical locations, reliance will be placed entirely upon fire protection, forest improvement, and planting to achieve a reasonable degree of control over existing slide or gully areas and minor watercourses. The cost of installing these measures is conservatively estimated at $300,000, or an average of about $8,000 per mile of affected slope or drainageways.

2. Adequate fire control.--Forest fires are to be controlled so as to create and maintain conditions favorable to high infiltration rates and improved soil moisture storage capacity. The objective is to restrict the average annual burn to 1/10 of one percent for all forest land included under the recommended program. Fire protection in the watershed is already adequate to accomplish this except for 662,300 acres in North Carolina. Almost half of this acreage has as yet no organized protection against forest fires. In such areas a complete system of organized protection is to be established and maintained. In the remainder of the deficient-protection area, fire protection measures are to be improved.

3. Woodland management.--The woodland-management measures consist of (1) timber marking and other services and guidance to landowners aimed at improving and safeguarding water-soil relationships by building up and maintaining on the land an adequate forest cover, (2) assistance and guidance on stabilizing areas along old logging roads and trails that are contributing to rapid runoff and to accelerated erosion as well as advice on location and proper installation of proposed new logging roads and trails, (3) fencing of woodlots and other protection of forest land from grazing and trampling by domestic animals.

The measures listed under (1) are very important. From a hydrologic standpoint, much can be done in this watershed through proper management of the forest cover to improve forest floor and soil conditions. Improvement of these conditions will not only increase infiltration rates but will provide for greater water storage space in the soil.

The second measure is also important. Many logged-over areas in the watershed are interlaced with abandoned logging roads and skid trails that are serving as active drainageways for concentrated surface runoff. Moreover, these deteriorating roads and trails contribute much sediment to streams from accelerating erosion. Correction of such conditions will be through installation of water spreading devices, gully checks, and related measures.

The third type of forest-management measure listed above deals largely with fencing of some 150,000 acres of woodland that are now being overgrazed by domestic animals. Because of trampling, mainly, these grazed woodland soils are rated low in hydrologic condition. Protection against such grazing will do much to increase infiltration rates of the forest soils and to reduce erosion.

4. Tree planting.--Land capability surveys indicate that approximately 163,300 acres now being used at least in part for crops, pasture, and hay, should be converted to forest use. Tree planting offers the quickest and most effective means of securing optimum hydrologic conditions on these areas. Accordingly, all such areas will be planted to trees.

5. Land acquisition.--Public acquisition is proposed for approximately 70,000 acres of watershed land now in critical condition. Because of deterioration, this land cannot be expected to receive, under private ownership, the treatment needed to build up and maintain optimum hydrologic conditions. Land recommended for purchase is vital for watershed protection purposes, is now in poor hydrologic condition, and contributes materially to floods. In general it is rough, steep, stony land located on upper slopes and ridge tops.

According to the proposal, approximately 10,000 acres of land in private ownership inside the Jefferson National Forest boundary will be acquired to insure correction of unsatisfactory watershed conditions. Elsewhere, an additional 60,000 acres of critical watershed land will be purchased by state or local governments.

Federal, Other Public, and Owner Participation in the Recommended Program - It is proposed that the Federal and state governments will participate in the acceleration and supplemental program to the extent required for flood control and such activities as:

1. Organized watershed fire control.
2. Acquisition of woodlands.
3. Technical services to private woodland owners.
4. Forest planting.

It is expected that all public agencies will improve and manage their woodland areas in accordance with sound watershed principles and that necessary public acquisition in areas outside of approved national forest purchase units will be financed by local agencies.

The owners of private woodland are expected to participate in various activities conducted on their lands.

Other Conservation Practices and Measures

Additional soil and water conservation practices and measures will be applied as needed for obtaining a proper combination with the mutually supporting measures listed above. These additional measures serve to complete a basic system of soil and water conservation and proper land

use in accordance with needs and capabilities of the land of the watershed. These will include other farm and woodland practices and measures that may be required to make more effective or facilitate the installation of the above measures. This will produce a practical workable combination of measures that will be most effective in providing runoff and waterflow retardation and soil erosion prevention.

GROUP II MEASURES - SUPPLEMENT TO LAND TREATMENT

Tributary Channel Improvement and Streambank Stabilization

A survey was made on sample tributaries of the Roanoke River watershed to ascertain the present condition of the tributary stream channels and the kinds and amounts of channel improvement measures which would be effective in alleviating flood damages.

The following tributary streams were selected as representative sample tributaries within the several physical land units. The North Fork Upper Roanoke River above stream gage at Lafayette, Virginia, to represent streams in the Limestone Valley area; Blackwater River above stream gage near Union Hall, Virginia, to represent streams in the Mountain-Foothills area; Falling River above stream gage near Naruna, Virginia, to represent streams of the Roanoke River drainage in the Piedmont Plateau; and Sandy River above stream gage near Bachelors Hall, Virginia, to represent streams of the Dan River drainage in the Piedmont Plateau. Figure C-1, Appendix C.

Channel improvement measures consisting primarily of brushing, snagging, and establishment of suppressive vegetation on the banks will be most practical and beneficial on the streams in the Mountain-Foothills and Piedmont Plateau. In some areas, however, varying degrees of channel dredging and realignment will prove beneficial.

Recommended Channel Improvement - Channel improvement is recommended for tributary streams in the Mountain-Foothills and in the Piedmont Plateau. This improvement consists of channel dredging and realignment, snagging, removal of logs and debris dams, and brushing as well as the removal of trees from the tributary stream channels and on top of banks up to bankfull stage. Logs and brush will be removed from the floodway to avoid future clogging of the channels.

In addition to the clearing and snagging operations of varying degrees of intensity, it will be necessary to establish suppressive vegetation to discourage the future growth of brush and saplings, and to stabilize the side slopes and banks of the channels.

Scope of Channel Improvement Operations - The quantity and types of channel improvement needed along the sample tributary streams examined were expanded to all similar tributary streams in the physical land units.

Brushing, snagging, and the establishment and maintenance of suppressive vegetation of 100 percent intensity will be needed on 2,265

miles of tributary streams. This same type of treatment, but with only 60 percent intensity, will be required on 213 miles, and with only 30 percent intensity required on 304 miles, making a total of 2,782 miles for which treatment is recommended. On parts of this same mileage additional works of improvement are needed in the form of channel dredging and realignment, in varying degrees. This type of improvement is recommended on 281 miles of streams, most of which are located in the Dan River Piedmont area.

Channel improvement operations described above will be beneficial in that stream discharge will be materially increased, flood damages will be immediately reduced, future maintenance costs will be minimized, and, in some areas, the productivity of the flood plain will be increased.

It is contemplated that the landowners will be responsible for the removal of logs and other debris from the floodway during the initial clearing operations. They will also be responsible for annual maintenance including the planting of suppressive vegetation and subsequent brushing.

UNIT COSTS OF OPEN LAND MEASURES

Unit costs for the installation and annual maintenance of the recommended measures were computed from available data and local information. Sources of this information included Federal and State Experiment Stations, Soil Conservation Service technicians, contractors, and others within or near the watershed. Unit costs are estimates as to types and quantities of labor and materials needed and are based on 1946 average prices.

The estimated initial cost per unit for installation and maintenance of recommended open land measures is shown in table E-3.

Installation and annual maintenance costs are divided between Federal, non-Federal public, and private sources according to the expected contributions and benefits (table D-14, Appendix D).

ACTIVITIES RELATED TO FLOOD CONTROL

Department of the Army

The Corps of Engineers has made investigations of the Roanoke River and its tributaries to determine the feasibility of a comprehensive plan for development of its water resources.

A report covering navigation, flood control, power development and irrigation is printed in House Document No. 65, 74th Congress, 1st Session, as was authorized under provisions of House Document No. 308, 69th Congress, 1st Session.

The House of Representatives, by resolution adopted August 28, 1940, requested the Corps of Engineers to review the "308" report to determine the advisability of an immediate development of improvements in the interest of flood control and allied purposes. The Review Report dated January 30, 1943 is printed in House Document No. 650, 78th Congress, 2nd Session.

A comprehensive plan for the proper development of the water resources of the watershed was devised. Recommendations were made for construction of 11 multiple-purpose projects for hydroelectric power, flood control, and low water regulation. A priority of construction was established for the plan of improvement.

The Flood Control Act approved December 22, 1944, authorized the construction of 11 reservoirs within the Roanoke River watershed as recommended in H. D. 650. Appropriations have been made for Buggs Island and Philpott projects, both of which are under construction.

Federal Participation - Woodland Phase

The Federal and State Governments are cooperating in organized fire control and in the production and distribution of forest tree seedlings under the Clarke-McNary Act. Over 85 percent of the woodland area in the watershed is now under organized fire protection. Farm forestry services are also provided under the Norris-Doxey Act. Similar cooperative activities between the Federal and state governments are concerned with the control of forest insects and disease. Under the provisions of Public Law 729, 81st Congress, 2nd Session, which will supersede the Norris-Doxey Act on June 30, 1951, these services have been broadened to include technical aid to non-farm forest owners and operators.

The Federal Government, through the U. S. Park Service, administers approximately 11,580 acres of park lands and the U. S. Forest Service administers approximately 12,338 acres of National forest land in the watershed.

The States and other public agencies in North Carolina and Virginia own approximately 29,600 acres of land in the drainage basin.

Educational Activities and Direct Aids

The agricultural colleges, vocational agricultural schools, and the U. S. Department of Agriculture Cooperative Extension Service have obtained local recognition of many farm problems and have also rendered valuable assistance by educating the public to appreciate the need for measures to conserve soil, water, and other natural resources.

Federal and State Experiment Stations within or near the watershed are constantly supplying data which aid in the solution of the soil, water, economic, and related agricultural problem.

The Production and Marketing Administration has assisted with "direct aids" in the establishment of conservation practices on individual farms.

Soil Conservation District Program

The states of Virginia and North Carolina have both enacted legislation under which soil conservation districts are actively operating throughout the entire drainage basin. The U. S. Department of Agriculture cooperates with these districts to the extent of supplying technical assistance principally through the Soil Conservation Service.

These districts are promoting a soil and water conservation program on farm lands. All of the conservation measures applied are in line with and support the recommended program.

Farmer Participation

The soil conservation district supervisors agree that the recommended program is practical and that greater intensity of application would be necessary on the seriously eroded, critical runoff and silt source areas. Considering the progressive type of farmers in the watershed, together with local interest in soil and water conservation, the supervisors are of the opinion that the landowners would cooperate and participate fully during the period of operations.

Highway Departments and Railroads

Officials of the highway departments and railroad companies in the two states are interested in erosion control to the extent that stabilization measures are now being applied on portions of principal highways and on railroad cuts.

It is anticipated that no difficulties will be encountered in obtaining the cooperation of these officials in the application of flood and erosion control remedial measures on the critical sediment-source areas of highways and railroads in the watershed.

Reservoir Operation

There are a number of municipally and privately owned reservoirs in the watershed. None of the existing reservoirs are large enough or are operated in such a way as to have any appreciable effect on reduction of floods.

ESTIMATED COST OF "GOING" PROGRAMS 1/

Estimated annual Federal costs of "going" programs are approximately $934,300.

1/ Adjusted to eliminate costs in Coastal Plain area.

Soil Conservation Service in Cooperation with Soil Conservation Districts

The fiscal year 1949 was used as a base for estimating the annual cost (including administrative and facilitating services) of the Soil Conservation Service assistance to districts in the watershed. The cost was determined by proportioning total personnel and facilitating costs on a basis of the percentage of watershed farm land in each district. Personnel cost represents salaries paid to local technicians. Facilitating cost represents transportation, office rent, supplies, administrative and technical supervision and related assistance. The estimated annual Federal cost is $204,000.

Forestry Activities

Forestry activities under the "going" program include work in forest improvement and management, and tree planting. Annual Federal costs are estimated at $30,600.

Cooperative Extension Service

Copies of supporting correspondence which was used as a base in estimating accomplishments and costs of this part of the "going" program are shown on pages 14 through 19. Total Federal annual cost is estimated at $58,600.

Production and Marketing Administration

Copies of supporting correspondence which was used as a base in estimating accomplishments and costs of this part of the "going" program are shown on pages 20 through 24. The annual Federal cost is estimated at $641,100.

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COOPERATIVE EXTENSION WORK
IN
AGRICULTURE AND HOME ECONOMICS
State of Virginia

July 1, 1950

Mr. H. G. Edwards, Chief
Regional Water Conservation Division
Soil Conservation Service
Spartanburg, South Carolina

Dear Mr. Edwards:

As indicated to you in my letter of June 22 we were somewhat at a loss to determine just how to arrive at an estimated cost to the Extension Service of additional educational assistance needed under an accelerated program in the Roanoke River Watershed Flood Control project. Since writing you, we have had an opportunity to discuss this matter with Mr. J. E. McLean of the regional office at Spartanburg. Based upon the information furnished us by Mr. McLean, we are submitting with this letter a statement relative to the present expenses on runoff, waterflow retardation, and soil erosion prevention in the area and a statement as to future expenses.

As stated in my letter of June 22, your letter of May 18 requested information upon the present annual cost of the educational work in the Roanoke River Watershed in Virginia. As far as we can determine, the cost of our present program in that area on runoff, waterflow retardation, and soil erosion prevention is around $109,951 annually. We arrived at this figure in the following manner. We first took the amount being spent on the Extension personnel in the counties in this area. To this figure we applied the percentage area of each county in the watershed. This gave us a figure for personnel in the watershed area. We then took the figure for the administrative costs, supplies, and equipment for the counties and applied the percentage figure to reduce it to a watershed figure. To the sum of the personnel, equipment, and administration figures for the watershed area, we applied a factor of 60% to determine the amount spent for runoff, waterflow retardation, and soil erosion prevention. We estimated that 60% of the agents and specialists time is spent on work, either directly or indirectly, of this nature. We consider that work on crop rotation, pastures, etc., would be applicable as well as the more frequently recognized practices such as strip cropping, terracing, etc.

Your letter requests that this figure for the present expenses be broken down as between Federal and non-Federal funds. At present, 44% of our Extension funds are received from the State Treasury, 14% from the county, and 42% from Federal sources. It would be approximately correct, therefore, to say that 42% of the $109,951 or $46,179.42 would be funds from Federal origin and that 58% or $62,771.58 would be of State and County origin.

Our greatest difficulty was in arriving at a figure as to future costs. Both Mr. T. C. Green of the Blacksburg Soil Conservation Service office.

and Mr. McLean were very helpful to us. The funds required to carry on an additional educational program in the Roanoke River Watershed on runoff, waterflow retardation, and soil erosion prevention will depend entirely upon how fast the job is to be done. If a specialist and several assistant agents were put on in the area immediately, the man years over a 20-year period would be rather heavy. However, if the work is to be done gradually over a period of years, the cost would be considerably reduced. It is our understanding that the work will be initiated gradually on sub-watersheds and that the entire project will not be started at once. Based upon this understanding, we feel that sufficient funds should be provided to put on two full-time men for the entire area. This would require 40 man years at an estimated cost of $300,000 for the 20-year period or an average of $15,000 annually. This sum would include salary, travel, and servicing of the men.

If the work progresses more rapidly than contemplated, more funds would be required. It is understood that from time to time it will be necessary to prepare a budget on the work based upon information as to what is contemplated in the immediate future. At such times more accurate estimates can be given.

This matter has been discussed with Associate Director W. H. Daughtrey and Director L. B. Dietrick and the estimates given represent our combined judgment.

With best wishes, I am

Yours very truly,

H. E. McSwain
Assistant Director

COOPERATIVE EXTENSION WORK
IN
AGRICULTURE AND HOME ECONOMICS
STATE OF NORTH CAROLINA
Post Office Box 5157
State College Station, Raleigh, N. C.

C
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P
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June 2, 1950

Mr. H. G. Edwards, Chief
Water Conservation Division
Soil Conservation Service
Post Office Box 612
Spartanburg, South Carolina

Dear Mr. Edwards:

In accordance with a request from Mr. Loy E. Rast, Acting Chief Regional Water Conservation Division, I am enclosing an estimate of expenditures by the North Carolina Agricultural Extension Service for Conservation Measures during 1949 and the additional resources which will be needed for "Flood Control" activities in the Roanoke Watershed.

The estimates with respect to expenditures were made from an analysis of the County Agents' Annual Reports for 1949 and the Extension Budget for the fiscal year 1949-50. A breakdown of the estimate by Counties is shown in Table IV together with some explanation of the entries in each column.

A summary of these expenditures is shown in Table I with total estimated expenditures during 1949 of $45,608.00. Table II is an estimate of the proportion of the total expenditures during 1949 from different sources. The percentages shown are the actual percentages for our total Extension Budget in this State. While this may be slightly different from the percentages within the watershed, we feel it to be near enough for this estimate. In Table III we have shown our estimate of additional Extension resources which will be required to give the necessary acceleration to our Extension Educational Program to assure reasonable attainment of the objectives.

While I realize these are estimates, I would like to point out that they were arrived at through careful study and analysis of the present program, and what we believe to be needed in carrying out the program over a period of years.

Yours very truly,

I. O. Schaub
Director

Enclosures

Estimate of expenditures by the N. C. Agricultural Extension Service for conservation measures during 1949 and additional resources required for "flood control" activities in the Roanoke Watershed

TABLE I

Estimate of Expenditures for 1949

County Agents and Specialists	$40,608
Administration, Supervision and Supplies	5,000
Total Estimated Expenditures	45,608

TABLE II Estimate of Proportion of Total Expenditures During 1949 from Different Sources

	Percent	Amount
Federal Appropriations	40.4	$18,425.63
State Appropriations	36.4	16,601.31
County Appropriations	23.2	10,581.06
Total	100.	$45,608.00

TABLE III Estimate of Additional Resources Required From Federal Funds

16 Man Years - for specific work in relation to Water-flow Retardation and Soil Erosion Prevention in the Roanoke River Basin Area	$120,000
Average Cost per Year for a 20 year period	6,000

Estimate of expenditures by the N. C. Agricultural Extension Service during year 1949 for activities in relation to run-off and water-flow retardation and soil erosion prevention in the Roanoke River Basin area.
Computations were made from County Agents' reports and budget

Counties	(1) Tot. days worked by Co. Agents	(2) % of tot. days Co. Agents devoted to Consv. Measures	(3) Amt. of Co. Agts. Budget Expended for Consv. Work	(4) Cost of Spec. Asst.	(5) Tot. cost of Consv. Work Done by Agts. & Spec.	(6) % Land Area of County in W/S Area	(7) Tot. Expenditures for Consv. Work in W/S area
Beaufort	892.5	21.2	3,838	750	4,588	4	183
Bertie	867.5	15.2	2,964	750	3,711	66	2,449
Caswell	536.0	42.3	7,259	990	8,249	90	7,424
Forsyth	952.5	20.4	5,139	540	5,679	23	1,306
Granville	894.0	26.5	5,630	1,140	6,770	32	2,166
Guilford	1,308.5	25.2	7,906	1,440	9,346	1	93
Halifax	1,103.5	20.3	4,801	450	5,251	42.5	1,807
Martin	1,174.0	19.3	4,593	690	5,283	74	3,909
Northampton	871.0	19.4	3,696	1,140	4,836	35	1,693
Person	880.0	29.0	5,940	840	6,780	50	3,390
Rockingham	1,462.0	23.9	7,514	1,440	8,954	76	6,805
Stokes	579.0	34.7	4,095	510	4,605	85	3,914
Surry	1,135.0	24.6	7,117	3,000	10,117	2	202
Vance	861.0	19.6	3,614	1,440	5,054	52	2,628
Warren	908.0	22.6	4,693	1,650	6,343	37	2,347
Washington	308.0	18.8	1,437	510	1,947	15	292
Totals	14,732.5		80,236	17,280	97,513		40,608

Explanation to
TABLE IV

Estimate of expenditures by the N. C. Agricultural Extension Service during the calendar year 1949 for activities in relation to runoff and water-flow retardation and soil erosion prevention in the Roanoke River Watershed

Explanation to Attached Chart -

Column 1 - Total Days Worked by County Agents. This is the total days worked by the County Agents and their Assistants during the year.

Column 2 - Percentage of Total Days County Agents Devoted to Conservation Measures. Percent of the total days worked which were devoted to Conservation Measures.

Column 3 - Amount of County Agents' Budget Expended for Conservation Work. Represents that part of the total budget for County Agents which was expended for conservation work. The entries in this Column were determined by applying the percentage figure shown in Column 2 to the total budget for the County Agents in each County.

Column 4 - Cost of Specialist Assistance. Entries in this column were determined on the basis of days Specialists devoted to work of a conservation nature and the average cost per day.

Column 5 - Total Cost of Conservation work Done by County Agents and Specialists. This is the total of Column 3 and 4.

Column 6 - Percent of Land Area of County in Watershed Area. The entries in this column were obtained from Mr. Loy E. Rast, Acting Chief, Regional Water Conservation Division, and represent the actual percent of the land area in each County as planimetered from a base map and adjusted to the Area.

Column 7 - Total Expenditures for Conservation Work in Watershed Area. The entries in this column are the same percentage of the total cost as the percentage of the County which is in the Roanoke River Watershed.

UNITED STATES DEPARTMENT OF AGRICULTURE
Production and Marketing Administration
609 East Main Street
Richmond 19, Virginia

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In reply refer to:
3-LU (River Basin)

May 25, 1950

Mr. H. G. Edwards, Chief
Regional Water Conservation Division
Soil Conservation Service
Regional Office
Spartanburg, South Carolina

Dear Mr. Edwards:

As requested in your letter of May 18, addressed to Mr. Bridgforth, we are herewith enclosing our estimated annual rate of Federal contributions under the Agricultural Conservation Program including administration for the portion of the counties in the Roanoke River Watershed as shown in the attachment to your letter. Administrative costs are included in these estimates.

Those items listed in your letter which are not included in our attached tabulation are not included in our program.

We enjoyed very much the opportunity of meeting with you and Mr. Green this week and your explanation of the report on the Pee Dee Watershed was very helpful to all of us. If we can render any further assistance to you in regard to the forthcoming report on the Roanoke River Watershed Survey, we shall be glad to hear from you further.

Yours very truly,

J. S. Shackleton, Jr.
Acting Executive Secretary
Virginia PMA State Committee

Attachment

Estimated annual rate of Federal contributions under ACP program including administration
Roanoke River Watershed
Virginia

	Terracing	Tree Planting	Perennial Legumes & Grasses	Sod Waterways	Pasture Improvement (old)	Pasture Est. (new)	Total
Appomattox - Contribution			$2,600.00		$2,600.00	$2,850.00	$8,050.00
Acres			450		600	180	1,230
Bedford - Contribution			14,300.00		28,700.00	17,600.00	60,600.00
Acres			4,350		8,700	1,300	14,350
Botetourt - Contribution			990.00		1,980.00	1,320.00	4,290.00
Acres			240		600	84	924
Brunswick - Contribution	$25.00		220.00		550.00	1,650.00	2,445.00
Acres	5		50		150	100	305
Campbell - Contribution		$25.00	4,400.00	$100.00	8,900.00	13,350.00	26,775.00
Acres		3	1,000	3	2,835	800	4,641
Charlotte - Contribution	525.00		2,100.00		7,900.00	10,500.00	21,025.00
Acres	95		480		2,400	675	3,650
Floyd - Contribution			1,550.00		2,700.00	575.00	4,825.00
Acres			350		700	35	1,085
Franklin - Contribution	225.00		8,200.00		16,500.00	16,500.00	41,425.00
Acres	50		1,500		3,000	1,000	5,550
Halifax - Contribution	2,200.00	60.00	5,500.00	330.00	22,000.00	27,500.00	57,590.00
Acres	500	10	1,000	10	5,000	1,700	8,220

Estimated annual rate of Federal contributions under ACP program including administration
Roanoke River Watershed
Virginia

	Terracing	Tree Planting	Perennial Legumes & Grasses	Sod Waterways	Pasture Improvement (old)	Pasture Establishment (new)	Total
Henry - Contribution	$330.00		$2,750.00		$6,600.00	$16,500.00	$26,180.00
Acres	75		500		2,000	1,000	3,575
Mecklenburg - Contribution	935.00		4,675.00	$ 50.00	14,000.00	25,000.00	44,660.00
Acres	210		850	2	3,400	1,700	6,162
Montgomery - Contribution			4,700.00		9,500.00	3,500.00	17,700.00
Acres			850		2,150	215	3,215
Patrick - Contribution			5,100.00		12,400.00	9,300.00	26,800.00
Acres			940		2,800	565	4,305
Pittsylvania - Contribution	3,300.00		5,500.00		11,000.00	33,000.00	52,800.00
Acres	700		1,000		2,500	2,000	6,200
Roanoke - Contribution			8,100.00	50.00	10,800.00	7,200.00	26,150.00
Acres			1,800	2	2,700	450	4,952
TOTAL - Contribution	7,540.00	85.00	70,685.00	530.00	156,130.00	186,345.00	421,315.00
Acres	1,635	13	15,360	17	39,535	11,804	68,364

UNITED STATES DEPARTMENT OF AGRICULTURE
Production and Marketing Administration
State College Station
Raleigh, North Carolina
May 2, 1950

Mr. H. G. Edwards
Chief, Regional Water Conservation Division
Soil Conservation Service
U. S. Department of Agriculture
Regional Office
Spartanburg, South Carolina

Dear Mr. Edwards:

As requested in your letter of April 24, 1950, there is attached information desired on the Roanoke River Watershed in North Carolina.

Very truly yours,

G. T. Scott, State Director
Production and Marketing
Administration

Attachment

cc: Paul Leaming, Program Coordinator, Washington, D. C.

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Present annual rate of federal contributions under the agricultural conservation programs for the Roanoke River watershed area in North Carolina

Practice	Units	Contribution Including Administrative Expenses
1. Terracing	2,134,700 feet	$28,256.00
2. Farm ponds	15,040 cu. ft.	1,909.00
3. Perennials (Kudzu, Sericea, and alfalfa)	1,388 acres	38,671.00
4. Drainage	2,300 acres drained	11,961.00
5. (a) Establishing pastures	3,691 acres	74,954.00
(b) Improving pastures	3,688 acres	56,170.00
6. Sod waterways	14,051,000 sq. ft.	21,400.00
7. Planting trees	6 acres	33.00
Total		231,354.00
Establishing Red, Alsike and Sweetclover 75 acres (which is not included in the above total)		450

Table E-1 units

Table E-1

		Cro	Idle	Other land	Total area
		Ac	Acres	Acres	Acres
Limestone Valley	Present	3	13,696	36,014	277,030
	Recommended	3	--		
	Net change	-	-13,696		
Mountain-Foothills	Present	13	40,893	83,251	1,135,098
	Recommended	10	--		
	Net change	-3	-40,893		
Piedmont Plateau	Present	79	314,757	475,055	3,932,722
	Recommended	73	--		
	Net change	-5	-314,757		
Coastal Plain	Present	13	10,865	69,292	786,350
	Recommended	13	10,865		
	Net change		--		
Total Drainage Area	Present	1,10	380,211	663,612	6,131,200
	Recommended	1,00	10,865		
	Net Change	-9	-369,346		

Table E-1.--Present and recommended land use, showing net changes in land use by physical land units
Roanoke River Watershed

		Cropland	Pasture	Kudzu	Lespedeza sericea	Perennial Legume and Grass	Woodland	Orchard	Wildlife	Idle	Other land	Total area
		Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Limestone Valley	Present	39,515	48,947	--	--	4,690	127,433	6,685	50	13,696	36,014	277,030
	Recommended	38,000	55,628	--	--	7,000	132,388	7,700	300	--		
	Net change	-1,515	+6,681	--	--	+2,310	+4,955	+1,015	+250	-13,696		
Mountain-Foothills	Present	137,756	81,565	365	210	1,947	779,387	9,584	140	40,893	83,251	1,135,098
	Recommended	104,980	98,803	1,287	3,862	20,445	806,660	10,200	5,610	--		
	Net change	-32,776	+17,238	+922	+3,652	+18,498	+27,273	+616	+5,470	-40,893		
Piedmont Plateau	Present	793,109	257,775	1,885	1,140	6,370	2,066,957	14,899	775	314,757	475,055	3,932,722
	Recommended	735,253	351,370	10,359	20,719	99,176	2,215,749	14,899	10,142	--		
	Net change	-57,856	+93,595	+8,474	+19,579	+92,806	+148,792	--	-9,367	-314,757		
Coastal Plain	Present	131,127	33,961	18	--	--	540,850	237	--	10,865	69,292	786,350
	Recommended	131,127	33,961	18	--	--	540,850	237	--	10,865		
	Net change	--	--	--	--	--	--	--	--	--		
Total Drainage Area	Present	1,101,507	422,248	2,268	1,350	13,007	3,514,627	31,405	965	380,211	663,612	6,131,200
	Recommended	1,009,360	539,762	11,664	24,581	126,621	3,695,647	33,036	16,052	10,865		
	Net Change	-92,147	+117,514	+9,396	+ 23,231	+113,614	+181,020	+1,631	+15,087	-369,346		

Table E-2.--Summary of watershed needs, estimated accomplishments under "going" programs and recommended program
Roanoke River Watershed

Measure	Unit	Watershed needs	Accomplished by "going" programs 20-year period	Recommended program
Land Treatment				
Open land				
1. Subwatershed waterways	Mile	420	--	420
2. Gully stabilization and sediment control	Mile	780	--	780
3. Erosion control along railroads and roadways	Mile	4,799	--	4,799
4. Diversion channels	Mile	1,637	1,149	488
5. Terraces	Mile	61,600	15,420	46,180
6. Perennial vegetation	Acre	146,240	146,240	--
7. Pasture improvement 1/	Acre	341,690	341,690	--
8. Pasture establishment	Acre	117,510	117,510	--
9. Field border plantings	Acre	11,000	4,940	6,060
10. Farm waterways	Acre	36,580	13,700	22,880
Woodland program				
11. Mountain Watercourse Control	Mile	38	--	38
12. Adequate fire control	Acre	3,154,800 2/	2,492,500	662,300
Woodland management:				
13. Management plans	Acre	3,154,800	168,200	2,986,600
14. Timber marking	Acre	3,154,800	168,200	2,986,600
15. Stabilize roads and trails	Acre	3,154,800	--	3,154,800
16. Protection from grazing	Acre	150,000	--	150,000
17. Utilization and marketing	Acre	3,154,800	168,200	2,986,600
18. Tree planting	Acre	181,300	18,000	163,300
19. Land acquisition	Acre	70,000	--	70,000
Supplementary				
20. Tributary channel improvement and streambank stabilization	Mile	2,782	--	2,782

1/ Estimated that approximately 88 percent of the present acreage in pasture is in need of improvement.

2/ Total future forest area 3,695,647 acres, less forest area in Coastal Plain (540,850 acres).

Table E-3.--Estimated initial cost per unit for installation and maintenance of recommended open land measures
Roanoke River Watershed

Measure	Unit	Installation	Annual maintenance
		Dollars	Dollars
Land Treatment			
1. Subwatershed waterways	Mile	1,200	100
2. Gully stabilization and sediment control	Mile	338	40
3. Erosion control along railroads and roadways	Mile	103	21
4. Diversion channels	Mile	106	24
5. Terraces	Mile	53	12
6. Field border plantings	Acre	31	5
7. Farm waterways	Acre	47	7
Supplementary			
Channel improvement and stream-bank stabilization	Mile	945	55

Note: The above are average costs per unit to the nearest dollar.

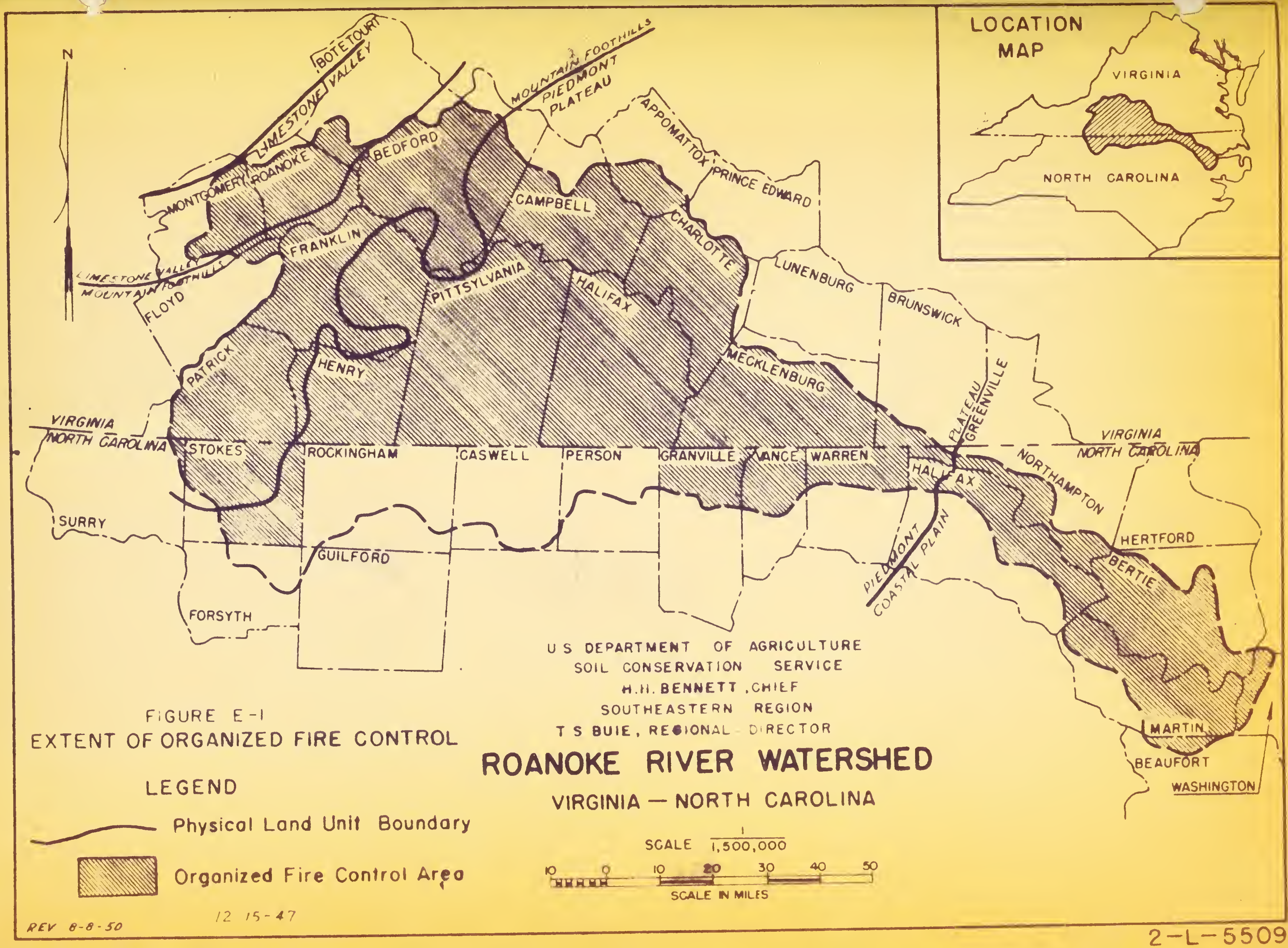

FIGURE E-1
EXTENT OF ORGANIZED FIRE CONTROL